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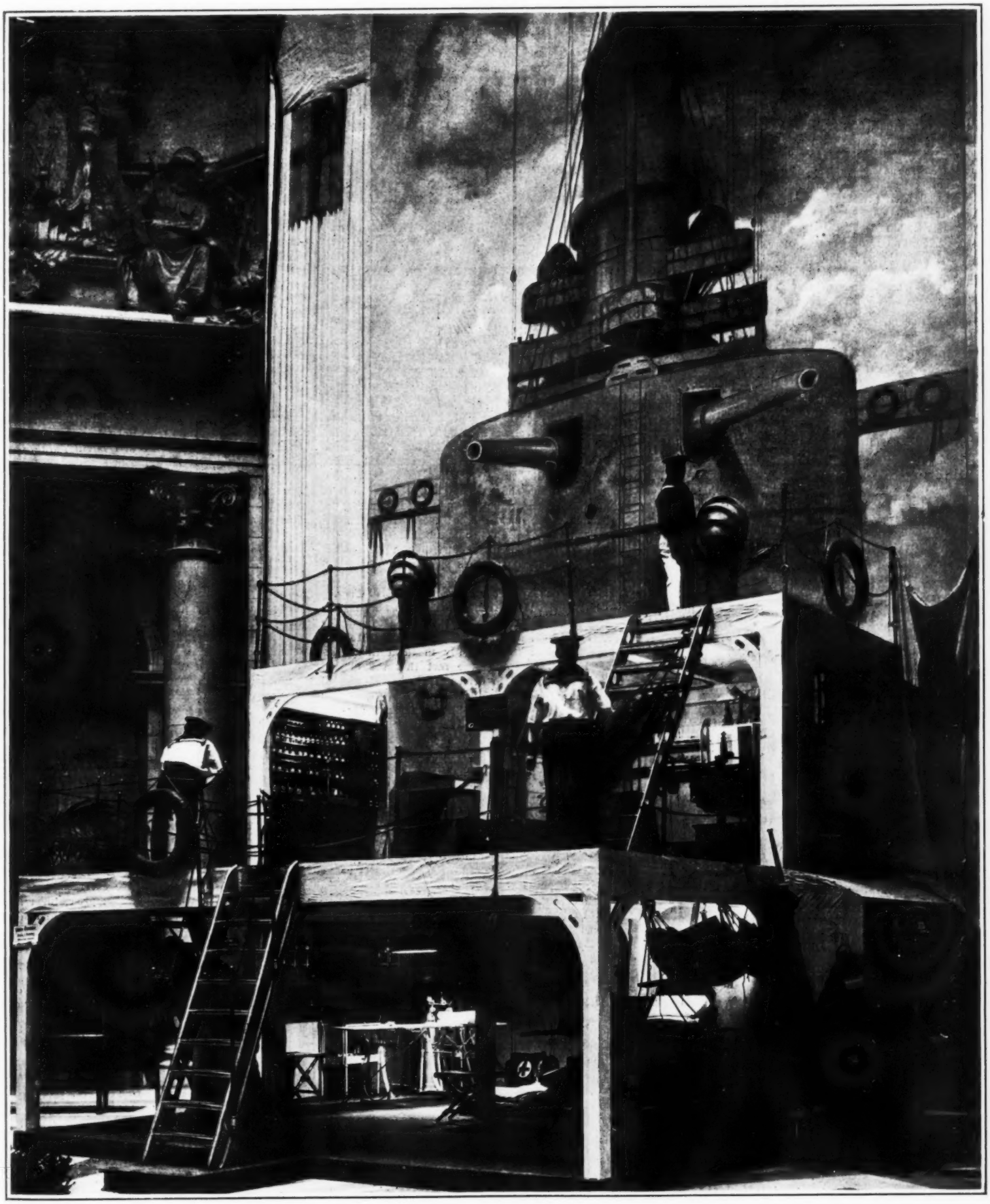


Scene at the sanitary exhibition at Berlin.

FULL SIZE MODEL OF A HOSPITAL ON A MAN-OF-WAR.—[See page 316.]

Pathology of Mental Disorders—I*

Modern Aspects of Certain Problems

By Edwin Goodall, M.D., Lond., B.S., F.R.C.P., Lond.

WHEN I was honored with an invitation to deliver these lectures before the college I deemed it a duty to make it clear that it would not, in my judgment, be possible for any one whose work lay in the domain of psychiatry to bring before you at the present time an array of substantial results, based upon scientific research, such as would for a moment compare with the results available for a general pathologist, a bacteriologist, or a worker in the general domain of pathological chemistry. This disability is doubtless recognized by those whom I have the honor to address; briefly, it depends, firstly, upon the inherent difficulties of the problems of the pathology of mental disorders, and, secondly, upon the deplorable separation of psychiatry from the other branches of medicine, in this country more especially—a separation which I am glad to believe is nearing its termination. In view of the comparative paucity of facts available for the purposes of my theme it is necessary that my range should be somewhat wide, and I shall have, broadly speaking, to deal with the results of pathological and bacteriological research, with problems of metabolism, with chemical and serological observations, and with certain therapeutic measures based upon observations in clinical pathology.

MORBID HISTOLOGY IN MENTAL DISEASE.

Already 20 years ago dissatisfaction with the results of histological research was expressed, and the advent of the worker in the field of biochemistry was desired. The histological work of those who had gone before was recognized as indispensable; while we were not so foolish as to believe that it was complete, it was nevertheless felt that the knowledge we possessed of the morbid histology of the brain in mental disease was not mean, and that the time had arrived when following the rational course, we should search for the pathological factors which had expressed themselves in the modes with which we were familiar. There remained, and there still remains, the problem as to the degree of responsibility of the histological lesions for some of the symptoms, perhaps characteristic symptoms, of this or that kind of insanity, by virtue of specific localization of lesions in specific kinds of insanity.

At the present time we have to record that there are in most cases of mental disease uncharacteristic brain changes, but, largely owing to the powerful impetus given to histological research by the work of Alzheimer and Nissl and their pupils, characteristic brain changes have been shown in mental disease associated with syphilis, in the progressive dementia which accompanies some cases of arterio-sclerosis and in senile dementia. On the other hand, the histological lesions found in the following clinical kinds of insanity are not characteristic: the kinds grouped under the term "dementia præcox," the alcoholic insanities, so-called manic-depressive insanity, acute delirious mania, insanity with epilepsy, though it be granted that in the last mentioned instance a diffuse cerebral gliosis is found in cases dying from intercurrent disease after years of the malady. There is no evidence of characteristic localization of the lesions found in the brain in the psychoses, either as regards the brain as a whole or as regards layers of the cortex cerebri, or constituents of the cortex, unless the involvement of the mesodermal elements in the psychoses primarily due to syphilis or associated with trypanosomiasis are so considered.

THE DEMENTIA PRÆCOX GROUP OF CASES.

I am not, I think, justified in detaining you with observations upon morbid histology in mental diseases further than is necessitated by a reference to the particular cases of, respectively, the dementia-præcox group and dementia paralytica. In studying the pathological anatomy of the cases nowadays grouped under the name "dementia præcox" we are faced with the difficulty that death seldom occurs in an early stage of the disease, and when it does it is due to intercurrent maladies, especially tuberculosis, which may themselves be partially responsible for the morbid appearances. The disease is not due to lethal causes; incidentally, the same is true of other psychoses, such as the systematized delusional disorders, and even manic-depressive insanity, as a rule. Zingerle[1] rightly points out that one must further discount appearances which may well be referable to mere congenital defect of development. There being no characteristic anatomical picture for the disorder as a whole, its subdivision, clinically, into three groups obtains of course no support from the standpoint of pathological anatomy. The points to be noted for verification from the observations made up to the present are: that, at any rate for the variety mentioned the lesions—of the individual elements—which are in no way peculiar, but are those found in many acute and recent mental disorders (degenerative conditions, as shown by modern methods in nerve and glia cells) are found throughout the brain, the cerebellum, and the basal ganglia; that they are especially pronounced in the deeper layers of the cortex cerebri; that they concern the ectodermal elements (degeneration) especially and the mesodermal to a much less extent (absence of inflammation). Should these observations be confirmed they would afford a means of distinguishing anatomically between this clinical variety of dementia præcox and such diseases as dementia paralytica, insanity due to lues cerebri, to arterio-sclerosis, and to chronic alcoholism, in which vascular and perivascular changes are marked. If confirmed, they would point to the conclusion that maladies which are associated with lesions so diverse must be unlike in pathogenesis.

DEMENTIA PARALYTICA.

In regard to the morbid anatomy of dementia paralytica, it is admitted that while none of the macroscopic or microscopic lesions is pathognomonic, these together form a whole which is characteristic. To the naked eye, the combination of the indications of long standing lepto meningitis, especially pronounced over the fronto-parietal area, of cortical erosions, of wasting of the prefrontal gyri and granularity of the ependyma of the ventricles, is characteristic. Histologically the diffuse nature of the infiltration, by products of inflammation, of the vessel walls, traceable throughout the vessels, including the finest, the tendency of the infiltration to keep to the vessel walls and perivascular area, the superabundance of plasma cells: these are characteristic. Some might claim that the multiplicity, the gravity, and the widespread distribution of all the lesions throughout the nervous system are characteristic.

Lesions in Dementia Paralytica and Cerebral Lues.

One has selected the frontal gyri almost as matter of course as the most likely ones in which to find the spirochæta pallida, and recent writers appear to find the organism with less difficulty in them than elsewhere. Having regard to the fact that the morbid histology of the brain in dementia paralytica, and in diffuse cerebral lues, I think I may also say, was—if we except plasma cells and rod cells—well known to pathologists in 1892, it is somewhat surprising to me that I cannot remember that anyone then pointed out the difficulty of differentiating between these two conditions by histological examination. The failure to recognize, or at any rate to lay stress upon, the resemblance between these two histological pictures I ascribe to the absence of co-ordination between workers in psychiatry and neurology, and to the fact that the importance of syphilis in the pathogenesis of dementia paralytica was not then recognized. It was not, I think, until by patient clinical observation, and inquiry into the histories of cases, evidence of syphilis was found in a large proportion that such evidence was sought for by the methods of morbid histology; and no doubt interest in this inquiry was further promoted by the results obtained by the application of the method of complement-deviation to the serum and cerebro spinal fluid of general paralytics.

Sträussler[2] (1911 and 1912) described six cases in which syphilitic lesions—such as meningitis and miliary gummata—coexisted with changes typical of dementia paralytica. I cite the above work as indicating how, in recent times, and in the light of better knowledge of the pathology of dementia paralytica, a close relationship has been found between the lesions of diffuse cerebral lues and of so-called metasyphilitic disease of the brain. The importance of the plasma cells in the latter has been exaggerated. I have already alluded to the extraordinary abundance of these elements in the brain of the general paralytic, and this appears to be a characteristic of dementia paralytica; I believe also of sleeping sickness. But they are not peculiar to any special disease; they have been described in cerebral lues, in non-specific encephalitis, and in non-specific foci of inflammation in the central nervous system.[3 4] They appear to constitute a mode of reaction to different toxic agents.

Relations of Dementia Paralytica and Cerebral Syphilis.

The demonstration of the existence in certain cases of diffuse cerebral lues and dementia paralytica of the same cerebral lesions, and the demonstration of mixed histological lesions, illustrating both conditions, in the same brain, leads to the suggestion that dementia paralytica is merely an unusually late manifestation of syphilis of the brain. The number of syphilitics who develop tertiary lesions in the brain is rare; according to Henschen,[5] of 754 only 17.85 per cent do so. The number developing dementia paralytica is still rarer; statistics place the incidence at 4-5 per cent. As to development of dementia paralytica in cases of cerebro-spinal lues, Mattauschek and Pilcz[6] found that of 116 cases of the latter condition only 2 got the former. This observation is particularly interesting. It is in keeping with the clinical, anatomical, and histological evidence furnished by typical cases of dementia paralytica, which demarcates the condition from cerebral lues. To this has to be added the evidence furnished by the studies in the metabolism of nervous and mental disorders which have been made in quite recent times, which, although doubtless in need of confirmation and amplification, go to show that in dementia paralytica there are well-marked disturbances which are not found in lues cerebri, so that some additional factor would appear to be operative in the former case. Nevertheless, atypical cases of dementia paralytica are not few, and in these it does not seem possible, whether by clinical, serological, anatomical, or histological means, to differentiate the condition from diffuse cerebral lues.

Neuropathic Inheritance in General Paralysis.

Those of us who have reached a certain age can recall that as students we were taught that this disease occurred in persons in whom as a rule no neuropathic inheritance could be found. Not only had their own lives been usually exemplary, with the possible exception of lapses in a remote youth, but they came from a sound stock. Naecke,[7] however, in numerous publications based upon most painstaking and prolonged investigations, has shown that hereditary predisposition to nervous disease is very considerable in dementia paralytica, scarcely less so than in other kinds of insanity, and that such certainly exists in 50 per cent of cases. Schroeder[8] finds neuropathic inheritance, and evidence of neuropathic disposition in the patient himself, in 77.8 per cent of cases. The observation of Schroeder, as to evidence furnished by the patient himself, points to the importance of seeking for evidence of defective development, as furnished by a study of the so-called "stigmata of degeneration," in the adult insane. In a paper published in 1899[9] I dwelt upon this subject, and submitted the scheme of examination I had been following; but in carrying out such inquiry we are met with the difficulty of obtaining control observations upon normal individuals of the same age-periods, social class, and district as the patients. Such controls would require to be carried out with the dead as well as the living subject, for there are of course anomalies of formation of internal as well as of external organs (internal and external stigmata). The above are no light hindrances. Observers are exceedingly few who have grappled with this difficulty; pre-eminent among them is Naecke. He asserts that external and internal stigmata are more frequent, grave, and widespread in general paralytics than in normal persons; he finds that in the former, in so far as the brain is concerned, microgyria, undersized frontal convolutions (especially), and the rarer variations or anomalies of the gyri and sulci, which especially indicate arrest of development, appear much oftener than in normal persons. The general paralytic's brain he regards as deficient *ab ovo*. Naecke quotes Vogt, who refers to observations by Roudonie of Florence, from which it appears that there is in the juvenile general paralytics

* Abstracts from a lecture delivered before the Royal College of Physicians of London.

[1] Zingerle: Monatsschrift für Psychiatrie und Neurologie, 1910, Hefte 4.

[2] Sträussler: Monatsschrift für Neurologie und Psychiatrie, 29, 1911; Zeitschrift für die gesamte Neurologie und Psychiatrie, Originale, 12, 1912.

[3] Klippel and Lhermitte: L'Encéphale, June 24th, 1909.

[4] Behr: Allgemeine Zeitschrift für Psychiatrie, Band lxvi.

[5] Cited by Allers: Zeitschrift für die gesamte Neurologie und Psychiatrie, Band xviii., Hefte 1 and 2, 1913.

[6] Cited by Allers: Zeitschrift für die gesamte Neurologie und Psychiatrie, Band xviii., Hefte 1 and 2, 1913.

[7] Naecke: Allgemeine Zeitschrift für Psychiatrie, Bände lv., lviii., lxv.; Neurologisches Centralblatt, 1899. No. 22; Allgemaine Zeitschrift für Psychiatrie. 1900. No. 16; Zeitschrift für die gesamte Neurologie und Psychiatrie, Originale, 1 and 3, 1913.

[8] Schroeder: Neurologisches Centralblatt, June, 1910.

[9] Goodall: *The Lancet*, July 15th, 1899, p. 149.

examined by him a cerebral cortex which in various details is immature (embryonal layer-formation, imperfect cells, anomalies of the medullated substance, etc.). Neuro-psychopathic inheritance in dementia paralytica is regarded by Junius and Arndt[10] as the next most important factor to syphilis.

Comparison of Sleeping Sickness and General Paralysis.

The fact that syphilis preceded general paralysis having been established, it was highly suggestive when attention was drawn to the fact that sleeping sickness—a condition having a remarkable clinical and pathological likeness to general paralysis—followed upon trypanosomiasis, a disease with points of resemblance to syphilis, as is well brought out by Browning and McKenzie.[11] According to Schaudinn the spirochæta pallida stands near the trypanosome in the protozoal group. It is to be noted that trypanosomiasis does not lead to sleeping sickness in all cases by any means; I do not know in what proportion the sequence occurs, but the point is of interest by analogy with the parallel circumstance in regard to syphilis and dementia paralytica. The curability of trypanosome fever and of syphilis contrasts with the incurability, at present, of sleeping sickness (the dementia of trypanosomiasis) and dementia paralytica.

In marked contradistinction to the infrequency with which the treponema is still found in dementia paralytica is the frequency with which the trypanosome was found by Vix in sleeping sickness (65 out of 70 cases, in the blood or cerebro-spinal fluid). Another distinction is that the proclivity of the frontal lobes to suffer in the former disease is not noticeable in the latter. The trypanosomiasis recently described as frequent in Brazil, otherwise known as Chagas' di ease, and due to the T. Cruzi (which is found in all regions of the brain in cases which run a chronic course and become demented) appears likewise to result sometimes in a condition resembling dementia paralytica.

Evidence of Toxic Process in Dementia Paralytica.

Cases of pellagra are on record[12] in which the psychical symptoms and neurological signs (reflexes, pupillary condition, speech) have resembled those of dementia paralytica, but the morbid anatomy of the brain was not inquired into. But before the evidence of antecedent syphilis was available, and long before the points of resemblance between sleeping sickness and dementia paralytica were known, the clinical and pathological evidence of the toxic nature of the morbid process in dementia paralytica was recognized as strong. From the clinical standpoint there are the exacerbations and remissions, very suggestive of recrudescence and quiescence of a toxic process; the variations of temperature, of unknown causation, and only found when the temperature is taken several times daily over long periods; and the seizures. The latter are comparable to those observed in uræmia and eclampsia. There is the polynucleosis of the blood in connection with exacerbations, and some would add that of the cerebro-spinal fluid. As regards morbid histology, the well-known changes in the walls of the cerebro-spinal vessels, in the perivascular and interstitial tissues of the central nervous system, are suggestive of a toxic process. But these changes, including infiltration of these tissues with lymphocytes and plasma cells, are not limited to the nervous system.

Spirochætes in the Brain Cortex in Dementia Paralytica.

Our knowledge may be summarized thus in regard to the demonstration in sections and films of the brain cortex.

Noguchi's statistics,[13] as published up to July, 1913, dealt with 200 cases; the organisms were found in nearly 25 per cent in sections. Marinesco and Minea[14] found them (apparently in sections) in 1 case out of 26—nearly 4 per cent; Levaditi, Marie, Bankowski,[15] in sections, in 3 out of 32—10 per cent. By the fresh film method of Fontana-Tribondeau (silver impregnation, after fixing and mordanting), Loeffler's fresh method, and dark-ground illumination they found the organism in 8 out of 9 cases—88.8 per cent. It is to be noted that the last-mentioned authors obtained these satisfactory results in cases which died in from 1 to 14 months after the diagnosis of the malady—that is, in rapidly progressing cases; furthermore, 8 of the 9 died from seizures. In Noguchi's original series rather more than one half of the cases averaged only 17 months in duration. In the case figured by Uhlenhuth and Melzer, in their "Atlas of Experimental Syphilis in Rabbits," a syphiloma was produced in the testicle by inoculation of brain material from a particularly early case of general paralysis. Scholberg and Goodall examined films prepared from the cortex of the frontal lobe on the morning upon which death occurred in 8 cases, all of them examples of long standing disease (dementia paralytica), the dark-ground, Indian ink, and Fontana-Tribondeau methods being used. In none were undoubted spirochætes found, although doubtful instances occurred in two of the cases. From the foregoing it appears that statements still vary considerably as to the frequency with which the spirochæte has been demonstrated in the cortex cerebri in dementia paralytica.

Changes in the nervous system as a result of experimental inoculation with material containing spirochæta pallida.—Although many more investigations are required, with parallel observations upon other tissues, it is obvious from those recorded by Jakob and Weygandt[16] and a few others that the entire nervous system is involved in changes of an inflammatory nature in consequence of inoculation of the spirochæte; the morbid process involving primarily the membranes and blood-vessels, with production of inflammatory foci, suggestive of gummata, of abundance of lymphocytes, plasma- and rod-cells, with gliaproliferation, and the like conditions, such as we are familiar with in sections of the general paralytic's brain.

Diphtheroid Organs.

There are bacteria found in the tissues of general paralytics which it is easy to dismiss as merely capable of inducing secondary inflammation, but I do not think we as yet are sufficiently acquainted with them to assert as much as this. While unable to follow Ford Robertson in his views as to the causative rôle in dementia paralytica of certain "diphtheroid" organisms described by him, I think it desirable that his results should be borne in mind, and not unlikely that the record of results obtained by the study of other bacteria will accrue to be collated with his. The diphteroid organisms described by Ford Robertson[17] have been shown by him in large numbers, and associated with inflammatory changes of the parts involved, invading the walls of the respiratory (including the nasopharyngeal), alimentary, and genito-urinary tracts, in the foci of catarrhal pneumonia which occur in cases dying in "congestive" seizures, in the walls of the cerebral vessels, in the perineural sheath of the trigeminus, in the pia-arachnoid, in the blood, and the centrifugalized deposit of the cerebro-spinal fluid, in the urine—in all these fluids especially after seizures. They invade the lymphatics of the parts involved. The mucosa of the tracts involved and the subjacent tissues present evidence of chronic inflammation. The bacilli have been cultivated from the blood, urine, and cerebro-spinal fluid. Rats and a goat inoculated with them from a case of general paralysis developed paretic symptoms, and histologically lesions closely resembling those of early general paralysis were found.

At this point I would refer to an interesting statement of Cerletti,[18] to the effect that in connection with "cimurro" (glanders) in dogs, mouths after recovery from the catarrhal infection, a demented state slowly supervenes, with ultimate cachexia and death. It appears that some veterinary surgeons regard this condition as the same as dementia paralytica. In it Cerletti has found a chronic encephalitis with diffuse lymphocytic and plasma-cell infiltration; and the cortical lesions he considers like those of dementia paralytica.

The Question of Lues Nervosa.

Since the demonstration of the spirochæte in the brain of general paralytics attention has been mainly focussed upon a particular problem in the pathology of the disease—namely, its relations to syphilis. The rarity of the disease in syphilitics, the mild nature of the antecedent syphilis in general paralytics, the clinical and pathological peculiarities of general paralysis, the difficulties surrounding the detection and culture of the spirochæte in general paralysis, the difficulty of inoculating animals with this organism as compared with the organism of ordinary syphilis, these and the like considerations have prompted the suggestion of a spirochæte with special affinity for the nervous system, the possibility, in other words, of a *lues nervosa*. The soil is often not a normal one, there being, as has been said above, evidence of neuropathic inheritance in a considerable proportion of general paralytics.

(To be continued.)

[10] Junius and Arndt: Archiv für Psychiatrie und Nervenkrankheiten, Band xliv., Heft 1.

[11] Browning and McKenzie: Review of Neurology and Psychiatry, vol. vii., 1909.

[12] Bondurant: Jahresbericht für Neurologie und Psychiatrie, vol. xvi., 1912.

[13] Noguchi's figures cited in Annales de l'Institut Pasteur; Tome xxvii., No. 7, 1913.

[14] Marinesco and Minea; Bulletin de l'Académie de Médecine, No. 12, 1913.

[15] Levaditi, etc.: Annales de l'Institut Pasteur; Tome xxvii., No. 7, 1913.

[16] Jakob and Weygandt: Münchener Medicinische Wochenschrift, No. 37, 1913.

[17] Ford Robertson: Journal of Mental Science, April, 1906; Ford Robertson and McRae; Ibid., July, 1907; Review of Neurology and Psychology, vol. vii., 1909, etc.

[18] Cerletti: Rivista Spermentale di Freniatria, vol. xxxviii., No. 4, 1913.

Electrical Engineering and Race Progress

To what extent has the science of the electrical engineer contributed to human development by improving human progress and efficiency?

The answer to this fascinating question may be found in the very thoughtful inaugural address which Dr. A. H. Railing gave recently as chairman of the Birmingham Local Section of the Institution of Electrical Engineers. As is pointed out in the address, electrical engineering is a power working for the forces of civilization if it enables us to make better use of matter, either by increasing the number of varieties of matter or by producing them more cheaply, or by making better use of their properties; if it enables us to make better use of the available energies; if it increases the space that can be inhabited and made use of by men; if it increases the physical or mental power and efficiency of each individual. Truly, the influence of electrical engineering in all these diverse directions has been, and still is, immense, and a treatise could be written on each. Dr. Railing contents himself with a few well-chosen examples. First, we see how ideally natural energy can be harnessed, as is the case with water and wind power—to give electric energy at an efficiency of 90 per cent on a commercial scale. Then there is the question of efficient transmission of generated energy, which can be effected so well that power lines of 50 to 100 miles in length, with 85 to 90 per cent efficiency, are in ordinary use, and this could be pushed still higher if free energy became so scarce that a higher capital outlay for the transmission line were advisable. The only alternative, transmission by radiation, while practicable and carried out for small amounts of energy, is yet impracticable for large quantities, for the same reason that light cannot be transformed conveniently into electrical energy, i. e., because an efficient mechanism of transformation has not yet been discovered. Here is opened up an excellent potential field for research.

Having shown how mankind can benefit from the ready generation and transmission of electricity, Dr. Railing next discusses some of its applications and their merits. Here we are on familiar ground discussing what electric lighting has done for the world, how "it makes us work more efficiently, obviates to a certain extent the differences between the seasons in countries of high latitudes, and prolongs in general the time of work and life under suitable sanitary conditions;" also the advantages of electric heating, "of which we are only at the beginning."

Besides these things electricity has given us a new metal in aluminium; it has allowed us to produce high-class steel in a new way; to produce new substances of great value to the world, e. g., carborundum and calcium carbide, besides having revolutionized the science of extracting metals from the ores. Electrical locomotion is another means whereby human progress has been advanced. It has increased the space which can be inhabited and made use of by mankind. Given a definite number of human beings, an increased rapidity of locomotion has the effect of decreasing distances, thereby increasing the radius of action for every human being. But electricity does more. Since it allows us conveniently to transform available energy, it is a great equalizer. It allows us to produce lower temperatures in hot climates and to produce heat in cold areas; it enables us to irrigate dry territories and thereby bring them under cultivation; it allows us to build canals and recover swamps. Activity of this kind is going on all over the world—in India and on the Panama Canal. It results everywhere in better living conditions, and increases the area that can be inhabited by man.

Finally, Dr. Railing reminds us of the applications of electrical engineering in the direction of the diagnosis and cure of certain diseases. There is the galvano-caustic apparatus for the local application of heat; the Röntgen apparatus and its ally radium, which with their bombardment of corpuscles allow us to see and reach internal tissues without using the knife.

Electrical engineering in thus mastering matter is trying to probe into the mechanism of living organism and problems which concern man's body and mind. These endeavors, in every result that they have achieved, and in every one that they will unravel, mean increase in the efficiency of the individual—the supreme mission of electrical engineering.—*The London Daily Telegraph.*

A Curious Property of Silenium

An interesting experiment with selenium was recently described to the Physical Society, in London, by Mr. A. A. Campbell Swinton. If selenium be mounted on a copper plate and placed in a glass cell containing an electrolyte—tap water by preference—with carbon or copper as the second electrode, the selenium proves electro-positive in the dark, but becomes electro-negative to carbon or copper immediately it is illuminated. Illumination is effected by an electric projecting lantern, a hole being pierced through the carbon or copper plate to allow the light to fall on the selenium.

Fig. 1.—Harvesting hemp on an Indiana farm.

Growing Hemp in America

Facts Relating to Its Culture, Qualities and Preparation

By Charles Richards Dodge

If there was ever a time when hemp culture in the United States ought to pay it is the present, as owing to the war in Europe the foreign supply has been considerably curtailed, and prices of all grades have been greatly increased. Our imports of this fiber are derived chiefly from Russia and Italy, the Italian hemp being a high grade, almost white, fiber of superior strength—in fact, the finest hemp produced in the world—and of which this country has taken as high as 4,000 tons in a year. The fiber imported from Russia is of lower grade, darker in color, not so carefully prepared, and of less tensile strength than the Italian, but well adapted to certain lines of American manufacture. The hemp grown in this country is, for the most part, quite inferior to that imported, being a very dark slaty gray in color, and more roughly prepared, but at the same time very strong and adapted to the manufacture of coarse twines and small cordage, for which it is largely employed.

In recent years the American culture has greatly declined, although between 50 and 60 years ago we produced in a year as high as 75,000 tons. But that was before the era of Manila hemp and jute, when common hemp was used for the manufacture of bagging—for baling the cotton crop—burlap, marine and other cordage, even clothing, and other lines. The importation of Manila hemp in increasing quantities started the decline, but the admission of jute butts, free of duty, in 1872, finished the business and drove every hemp mill out of existence. The production of hemp fell to 12,000 tons a year, and in recent years the production has fallen to 5,000 tons or less. Last season's crop is said to have been under 1,000 tons.

While our hemp imports are limited to the fiber of only two or three countries, the plant is almost universally grown. A native of central and western Asia, it has been carried by cultivation into all temperate and tropical climates. It is cultivated in central and southern Russia, Hungary, Germany, France and Italy, and in many portions of Asia—India especially, where it thrives at an elevation of 4,000 to 10,000 feet—and in China and Japan. It is found on both the east and west coasts of Africa, and it has been introduced into Victoria. It is as widely cultivated in the Western Hemisphere, and has been naturalized in South America north of Rio Janeiro. In the United States the culture has been carried on chiefly in Kentucky, Indiana, Illinois, Missouri, Minnesota and California, though the main supply has been produced in the first named State, where the plant has been cultivated for a century. Last year's crop is said to have been the smallest on record, owing, it is claimed, to tariff changes, and in Kentucky to the fact that there is more money in tobacco raising—the low prices that have ruled making the culture unprofitable.

Prices have ranged from 3½ cents to 6 cents per pound, Russian hemp bringing 7 and 8 cents, with a supply equal to any demand. Now that the American supply is next to nothing, the foreign supply curtailed, and prices soaring—a fair grade of imported fiber bringing 12 cents per pound—it would seem worth while for American growers, especially in Kentucky where the culture is so well understood, to put in an extra crop this year, and pocket the proceeds.

If the European war should continue for several years, as Lord Kitchener predicts, the foreign supply—of Russian fiber at least—may be still further curtailed, and Italy has already put a limit to the amount of hemp that can be exported. However, Italian hemp is too costly for most uses by American manufacturers. In any event there is sure to be a demand for American-grown hemp at fair prices. But to secure "war prices" the quality of the fiber must be improved so as to more nearly resemble the grades of imported hemp with which it would compete.

American hemp is generally dew-retted, that is, the stalks, after harvesting, are spread evenly over the ground in order that the gums which hold the filaments of fiber together may be softened and dissolved by the action of the elements and by freezing and thawing in the early winter storms. This method of retting is practised to a very small extent in Europe where the usual custom is to ret in pits or pools of water, which insures a more even quality of fiber, and a lighter color. American water-retted hemp has been sold at 8 cents per pound when dew-retted was bringing half that figure. When American hemp was used in the United States navy, before the days of Manila and steel cable rigging, the fiber was required to be water-retted.

Hemp is a plant of easy growth, as it flourishes in a wild state in many parts of the world, and in portions of our own country, where it has escaped from cultivation. But simple growth, and growth for good fiber are two very different things, and a farmer going into the culture without knowledge, and a certain degree of skill, will be likely to have only his labor for his pains. Skill is particularly required in the after preparation, when the crop has been grown—that is to say, in the retting and cleaning of the fiber.

To insure the best results in the culture the work should begin the previous fall, when the land is plowed, to be followed by spring plowing and harrowing, for the the ground should be finely prepared. Limestone soils are particularly favorable; clayey loams, or alluvial soils such as are found in the river bottoms are best adapted to this plant, the larger part of the Breton hemp of France being produced along the smaller streams. Light, or dry soils, or heavy tenacious soils are most unfavorable. Kentucky growers, and some in other States, use no fertilizers, claiming that it is not necessary, as the plants do not exhaust the soil, a leading grower in giving his experience stating that he had produced crops for 15 years, successively, on the same land. While this may be true regarding many localities, doubtless the fiber produced could not have competed with even low-grade imported hemp. When New York was a hemp growing State, hardly two decades ago, the growers considered the use of fertilizers of first importance. The foreign

Fig. 3.—Breaking hemp by machinery. A hemp gin in operation.

practice has always been to use fertilizers liberally.

In France a rotation of crops is practised, hemp alternating with grain crops; although competent authorities state that it may be grown continually on the same land, but not without fertilizers. In Italy where the highest grades of fiber are produced, and rich, strong loams are chosen for the culture, the land is highly fertilized. Here is the pratice that was formerly followed in Bologna: First, manure and olive husks; second manures (sometimes hen manure); third, manure and the chrysalides of silk worms; fourth, manure and more olive husks—a "mixed diet," but very efficacious. The tough hemps of Japan and China are largely due to the heavy fertilizing given the soil with barnyard manures. The general practice in Kentucky is to burn the refuse, after cleaning the fiber, and spread the ashes over the land. In a few words, the highest results can only be attained by following in a measure the practice requisite for producing a crop of fine flax fiber, the chief essentials being a thoroughly well prepared seed-bed, and proper fertility of the soil. Weeds are the bane of the flax-grower; but the hemp-grower need not fear them as the hemp plant is a most thorough weed exterminator, and a crop of hemp is sometimes put in to clean a piece of land that has become over foul with the seeds of troublesome weeds.

Of equal importance with soil selection is seed selection, and a well filled seed should be chosen, of a light gray color, glossy and heavy. Mr. Dewey, of the Department of Agriculture, informs me that in a recent letter from Messrs. Glass and Glass of Camp Nelson, Kentucky, it is stated that they have some seed of the Minnesota No. 8 variety, which has been developed by selection at the Minnesota Experiment Station and the Department of Agriculture. Some of the plants of this variety in the seed-breeding plot of the Department, the past season, averaged 3.05 meters high. Regarding the proper quantity of seed to sow practice differs. In France 1½ bushels per acre is considered the proper amount; in Italy 2½ bushels; in New York as high as 3 bushels were sometimes put in, while in Illinois 1 to 2½ bushels are used. The general rule followed in Kentucky for many years has been to use 33 pounds per acre, sown broadcast and dragged in. The method of broadcast seeding employed generally in that State is to use the ordinary grain drill, after removing the rubber tubes, and attaching a board just under the hopper, to catch and scatter the seed as it falls, the drill hoes just behind doing the covering.

After the seed is in the ground there is nothing further to be done until the plants are grown, and the stalks have reached their maturity, which is determined by the finding of ripe seed in the heads—in Kentucky the average time is about 100 days. Harvesting was done formerly with a heavy, hooked implement something like a sickle, but more recently the work of cutting has been accomplished by machinery. The use of sweep-rake reapers has become common, although in some localities an ordinary mowing machine is employed, with a horizontal bar attachment placed about 4 feet above the cutting bar, to bend the stalks over in the direction that the machine is moving. It is said that with a 5½-foot mowing machine, thus equipped, one man and a team of two horses will harvest 6 to 8 acres a day. After cutting, the stalks may be allowed to remain on the ground as left by the machine, although if the crop is heavy they should be turned, as required, to assure uniformity in the curing. A better practice, but one which entails more labor, is to let the stalks lie until the leaves have fallen off, when they are made into small stacks and allowed to remain in stack for a period of two months, after which they may be spread over the ground to be retted. The advantage is that winter-retted hemp is brighter than that done in October.

In these days of highly improved and efficient labor saving machinery, it is somewhat remarkable that the greater portion of the hemp fiber prepared in this country is cleaned on the clumsy wooden slat brake that has been used in Kentucky probably for a century (see Fig. 2). I found a similar form of brake in use in Brittany, though of lighter construction, being made of both metal and wood, and having seven instead of five slats. Breaking hemp in Kentucky, by hand, is an expensive operation, the work usually done by negroes, costing $1 to $1.25 per hundred pounds of fiber, and the best workers can clean no more than 150 pounds per day. Only half this quantity is done on a Sarthe farm in France, but the fiber is very much better prepared, and is worth twice as much money. A very primitive machine has been used in Italy, which first crushes the stalks, then cleans the fiber by beating; before the hemp is ready for market, however, it is still further cleaned, and all extraneous matters removed.

It is claimed that nearly 300 patents have been issued in the United States for machines for breaking hemp, the majority of which have proved absolute failures, while only a few have been found practical, most of these turning out inferior fiber. One of the most successful machine brakes, known as the Shely hemp gin (Fig. 3) has been in limited use in Kentucky and elsewhere during the past eight years. The device, mounted on wheels, weighs 7 tons, and is drawn by a farm traction engine which supplies the power when working. With a crew of fifteen men it will turn out 1,000 pounds per hour of clean, straight fiber, ready for baling, the broken fiber and tow being thrown out with the chive and waste matters. In this machine the stalks are fed sidewise and the delivery of the fiber is made in exactly the same manner.

Fig. 2.—Breaking hemp by hand.

Regarding the cost of hemp production 20 years ago in Kentucky, the expense was estimated at $24 per acre with an average yield of 1,000 pounds of fiber. A crop of Japan hemp, grown in Kern county, California, cost, including baling and freight to market, $67 per acre with a return of 7,000 pounds of fiber. In an article on "Hemp" in the year book of the Department of Agriculture for 1913, Mr. Dewey gives the total cost per acre at $35 (on the basis of a 50-acre plot) with a return of 750 pounds of long fiber and 210 pounds of tow—yielding a profit of $20 per acre. The long fiber is figured at 6 cents and the tow at 4 cents per pound. In considering these figures it must be remembered that every cent added to the selling price of the fiber is just so much clear profit. That is to say, the expense account being already settled, an advance of 4 cents per pound—or 10-cent hemp—on the basis of 1,000 pounds of fiber per acre, would mean $40 additional profit. Surely, at the present high prices of hemp, the American culture ought to pay, without regard to tariff considerations.

The illustrations in this article are from negatives by Mr Dewey, Fiber Botanist at the Department of Agriculture.

Gunshot Wounds in War

DELIVERING a Hunterian oration before a meeting of the Royal College of Surgeons, recently, Sir Watson Cheyne described several interesting experiments which he had carried out regarding the disinfecting of gunshot wounds prior to their being more elaborately dealt with at a base hospital. By means of microscopic lantern slides the lecturer demonstrated the effects of various antiseptics on colonies of bacilli which had been placed on waxy substances, representing suppurating sores. With the exception of one case, where a composition of corrosive sublimate had entirely dispelled the bacilli—much to the surprise of the lecturer—carbolic acid and creosol had proved the most effective. The experiments, he said, had been carried out by a committee formed of Fleet Surgeon Basset Smith, Mr. Arthur Edmunds (attached to the Royal Naval College at Chatham), and himself, and they proposed to pursue these further in the endeavor to solve the problem of effectively dealing with gunshot wounds, which had mystified medical men for ages past.

The object in view was to introduce into such wounds at the earliest possible opportunity after infliction an antiseptic which would remain there, diffuse in the blood of the tissues, and inhibit the growth of the bacteria until such time as the wound could be thoroughly disinfected. He felt sure from the experiments carried out that the dangers attending the necessary delay in conveying wounded from the firing line to the base could be entirely removed, and was hopeful that complete disinfection of wounds could be effected. Such problems, however, could only be solved at the front.—*The London Daily Telegraph.*

Atoms and Ions—III*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O. M., F. R. S.

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2053, Page 291, May 8, 1915

IN opening his third discourse, the lecturer said that he proposed that afternoon to discuss the subject of ionization as a result of chemical reactions. Had he been lecturing on this topic ten years ago he could have spoken with much less uncertainty as to the reality of this phenomenon than it was possible to do to-day. For many years, indeed for most of the past century, physicists held, with the utmost confidence, the opinion that chemical action formed one of the most efficient ways of producing electrification. The methodical studies of recent years had, however, shown that the experiments relied on for proof of this proposition were really vitiated by spurious effects. Uncertainty, in fact, arose from two distinct causes. In the first place, electricity was produced when a gas bubbled through certain liquids, and this fact put out of court all the experiments in which gas was generated as the result of a wet reaction. Another disturbing factor was that at high temperatures solid bodies gave out electricity. Many chemical actions were accompanied by a great rise of temperature. Hence, if solid particles were present as a result of the reaction, these would necessarily be at a very high temperature, and would give out the electricity which was formerly attributed to the chemical action.

To illustrate the effect of the source of uncertainty first alluded to, Sir Joseph Thomson placed on the top plate of an electroscope a lead dish containing zinc. On adding hydrochloric acid the electroscope was rapidly discharged, owing to the electrification of the hydrogen generated.

For a long time, Prof. Thomson continued, it was not doubted that in this experiment the electrification was directly due to the liberation of the hydrogen from the acid by the zinc. If this were so, however, in whatever way the acid acted on the zinc, the hydrogen produced should be electrified. In some very beautiful experiments Bloch had, however, shown that when the reaction took place between gaseous hydrochloric acid and finely divided zinc, there was no electrification whatever. The reaction was the same as before, the only difference being that it was not accompanied by the bubbling through liquid of the gas liberated. This experiment proved that former interpretations of the original experiment had been erroneous.

As matters stood there were undoubtedly many chemical reactions which were not accompanied by any perceptible electrification. A very interesting case was that of the combination under diffuse light of hydrogen with chlorine to form HCl. This reaction was one of the most vigorous known, and he had himself employed the most delicate means to detect whether any electricity was liberated by it, but the results were absolutely neutral, even when the rapidity of the reaction were pushed as far as was consistent with the safety of the apparatus. Another very vigorous reaction was, he continued, the oxidation of nitric oxide when allowed to escape into the air.

By adding nitric acid to copper the lecturer liberated nitric oxide, which was passed through a filter of cotton-wool to take out any ions due to the bubbling of the gas through the liquid as it was generated. The gas thus cleaned was then directed on to the top plate of an electroscope, and the copious red fumes produced bore evidence to the vigor of the reaction in progress. The electroscope showed no signs of leakage, in spite of the large amount of chemical action in progress.

The cases so far treated were, Sir Joseph proceeded, instances of chemical combination, but processes of dissociation were equally characterized by an absence of electrification. One very interesting instance was the decomposition of nickel carbonyl, which was effected by heat at a temperature below that of boiling water. The nickel was deposited as a bright mirror, and carbon monoxide liberated. This reaction, he said, had been very carefully investigated in the speaker's laboratory by Prof. Smith, but not the slightest sign of any accompanying electrification was to be detected. The dissociation of arseniuretted hydrogen, which also decomposed at a comparatively low temperature, had been studied by Bloch with equally negative results. In fact, while it was easy to give instances of chemical reactions which showed no ionization, he would be hard put to it to give a genuine case in which chemical action was accompanied by ionization.

The matter might, moreover, be regarded from the viewpoint of the energy changes involved. In the last lecture he had given a list of the energies required to ionize atoms of different elements; that was to say, the amount of work necessary to detach a negative particle from one of these atoms, so as to leave it electrified. Of all those given in his list mercury was by far the easiest to ionize, requiring 4.9 volts, while oxygen required 9 volts, and hydrogen 11 volts. Hence, to electrify an atom of hydrogen or of oxygen would require an expenditure of work represented by at least 9 volts. If this energy had to come from that liberated by chemical action, one would expect that the energy liberated on the combination of hydrogen and oxygen to form water should be greater than 9 volts. As a matter of fact, however, it amounted to a little less than 2 volts. Hence it would appear *à priori* that there was not enough energy available from the chemical combination to effect electrification of either the oxygen or the hydrogen atom. Indeed, the smallest of the numbers given in his list of the previous week represented an energy greater than that developed in any known chemical reaction. Possibly, if the list were extended to include such electro-positive elements as sodium and potassium, this might no longer be true.

Nevertheless the apparent insufficiency of the energy available did not entirely dispose of the question as to the possibility of ionization by chemical action. This would be the case if it were permissible to imagine that chemical action consisted in one molecule of a gas rushing past that of another and seizing on it; but, as a matter of fact, the marriage of the atoms did not take place in this haphazard way. It was not merely the result of chance collisions between particles rushing through space at velocities comparable with those of our largest projectiles. Such marriages always occurred in regions more densely populated than the average—viz., where the gas was condensed on the walls or on nuclei floating in the gas. This being so, it might quite conceivably take less energy to electrify the atom or molecule in a solid or liquid condition than in the gaseous state.

In his first lecture he had shown, the lecturer said, that when ultra-violet light fell on a clean zinc plate, negative electricity was liberated and escaped, leaving the zinc positively electrified. Now there was reason to believe that a definite amount of energy was associated with each kind of light, this amount being inversely proportional to the wave-length. Thus, in the case of the mercury line having a wave-length of 2,536 Angstrom units, the energy associated with this wave-length corresponded to 5 volts, which was that required to ionize the mercury atom, and light of this wave-length could accordingly ionize mercury vapor. This light lay in the ultra-violet; and in the visible spectrum, the wave-length being longer the associated energy was correspondingly less, and if one went up to the extreme limits of the red—viz., to wave-lengths of about 7,000 and 7,500 Angstrom units—the energy available for ionization would be only about one third of 5 volts, or, say, 1.6 volts, which was not greater than was liberated in certain chemical reactions. This red light, though of too long a wave-length to be visible, was, nevertheless, competent to cause a liberation of energy from certain kinds of solids.

To show this, the lecturer employed a glass vessel coated inside with a very thin layer of rubidium. The interior of the vessel was connected by one electrode to an electroscope, and by the other to earth. The light which passed through the ruby glass of a photographic lamp was allowed to act on this rubidium cell, all other light being excluded, and under these conditions the electroscope showed a very rapid leakage of electricity. This occurred, although the wave-length of the light reaching the rubidium was very long, and had associated with it a correspondingly small amount of energy. These rubidium cells were, the lecturer said, quite as sensitive to light as the eye; in fact, some workers claimed them to be even more sensitive. The glowing carbon of an extinguished match would, he said, excite the cell so long as any visible redness remained.

From this experiment it appeared that if we were dealing with solids, the energy available in chemical reactions might be sufficient to provide for that required in ionization, and the rubidium cell was, in fact, relied on as a proof of their case by those who regarded as established the reality of ionization by chemical means.

A great number of experiments had, in fact, been made by Haber and Just with this cell, and also with another in which the rubidium was replaced by the curious liquid alloy formed by potassium and sodium. This alloy, the speaker continued, closely resembled mercury in appearance, and he recalled incidentally its use by an American inventor in an attempted fraud on Prof. Rowland. The latter had been commissioned to investigate certain claims made by this inventor, and reported that if these were justified, it should be possible to make a barometer in which the mercury would stand far above the normal 30 inches. The inventor accepted the challenge, and brought forward one in which the liquid (to all appearance mercury) stood at a height of some yards. Investigation showed that the mercury had, in fact, been replaced by the sodium potassium alloy.

This alloy, Prof. Thomson continued, liberated electricity under the action of light just as rubidium did. Haber and Just used rubidium inclosed in a highly exhausted vessel which they kept in the dark, and into it they passed small amounts of bromine or of phosgene gas. On the entrance of this gas electricity was liberated, and on determining in the usual way the nature of the carriers, these proved to be negative particles. The experiment was repeated several times, and in all cases it was found that the liberation of the electricity took place when one of the above-mentioned gases was admitted. They attributed this ionization to the chemical action. It was conceivable that they were correct, but many difficulties would have to be overcome to be sure of a clear-cut issue, even in what was apparently so very simple an experiment.

The speaker had himself, in experiments made some years ago, used rubidium inclosed in a vessel exhausted to the highest degree by means of charcoal and liquid air. Though the cell was kept in the dark, some electricity was always liberated, even under the very highest vacua, although neither bromine nor phosgene gas was present. The apparatus was kept in the dark, and in a specially darkened room, the efficiency of the precautions taken being tested by exposing a very sensitive plate alongside the apparatus for four days. This plate, when developed, was quite clear from any signs of fog. Nevertheless, electricity was liberated, even at the highest vacua. He found, however, that its amount was very much increased by the admission of small quantities of hydrogen, which intensified the rate of leakage several fold. It was therefore not at all clear that in Haber and Just's experiments the effect of the gas admitted was due to its chemical action on the rubidium.

He would just allude to some results which showed the immense influence which might be exerted by films of gas formed on the surface of metals. A very conspicuous example was that of the emission of electricity from hot bodies. A platinum wire raised to a moderate red heat gave out a large amount of positive electricity. If the same wire were, however, cleaned with nitric acid and hydrogen eliminated with every possible precaution, the electricity liberated, at the same temperature as before, fell to less than one millionth of its former value. The presence of a film of hydrogen on the platinum had, therefore, an enormous effect. Another case was afforded by the action of light on rubidium itself, or rather on other metals which would not oxidize. The action light on such metals was recognized as being very fickle, and this variability was due to layers of gas condensed on the surface of the metal. If this layer were increased or removed, the effect was extraordinarily large.

The action of such films might be explained by imagining that this gaseous layer was electrified. If the electrification were positive, it would help the light to pull out negative particles from the metal. The effect would, therefore, be due to something which was not what was ordinarily implied by the term "chemical action." Hence it was not possible as yet to say whether photo-electric effects due to light of very long wave-length was not responsible for the results observed by Haber and Just. Light of this character was found even inside a closed box, and the electrical effects found might be due to a layer of gas condensed on the surface of the metal. Certainly some experiments showed that no electrification was obtained if the layer of gas were removed. Many experiments, for example, had been made with potassium, with which similar results to those observed with rubidium were obtained. By redistilling the po-

* Reproduced from *Engineering*

tassium half a dozen times from vessel to vessel, so as to free it from gas condensed on its surface, it was found that no photo-electric effect was to be observed, although ordinarily the metal responded readily even to feeble light of quite long wave-length. This was strong testimony to the great influence of surface layers, and made it all the more difficult to be sure that the effects observed by Haber and Just were not really attributable to a surface film and not to chemical action.

Methods of measurement were now so perfect that almost infinitely small amounts of electrical dissociation of a gas could be detected. Thus in a gas strongly electrified by means of Röntgen rays, not one molecule in a million was electrified. The speaker had worked out from a formula of Boltzmann the number of particles which would be electrified in a gas at different temperature in virtue of the molecular collisions. Denoting by N_0 the number of molecules not electrified, by N_1 those negatively electrified, and by N_2 those positively electrified, the formula arrived at was:

$$\frac{N_2 V}{N_1 N_2} = \frac{\pi a^2 \Sigma \overline{R\theta}}{\frac{w}{\overline{R\theta}}}$$

where V denoted the specified volume of the gas, $R\theta$ the energy possessed by a molecule (about one thirtieth volt at 0 deg.), a the radius of the atom or molecule, and w the energy required to ionize a particle.

This equation, he should add, represented an ideal to which the phenomena in question might attain, but which need not necessarily be reached within a finite time. All such expressions were obtained by finding an arrangement which gave the minimum value of some function. Thus in the simple case of the equilibrium of bodies under gravity, the general theorem was that the State was most stable when the center of gravity of the whole masses involved was at the lowest possible level.

If this were accepted without qualification, we should expect to find the whole population of the globe concentrated in its nethermost pits. Such formulæ, however, made no allowance for difficulties to be overcome in getting there. Water in a glass on the table was, from the viewpoint of the general theory, less stable than if spilt on the floor; but before it could escape to the latter it would have to have work done on it to raise it above the edge of the glass. Again, calculations based on these very general principles led to the conclusion that if hydrogen and oxygen were mixed together at ordinary temperatures, a by no means insignificant proportion of water would be formed. There was, however, reason to believe that the two gases might be left together for centuries without sensible combination occurring. In fact, for the reaction to proceed, an uphill road had to be traced at the outset, and a catalytic agent was needed to surmount the rise. Such an agent acted as a siphon would in emptying a lake into the sea. It absorbed no energy, but helped the system uphill.

Premising this, the formula given showed that at 2,000 deg. Cent. about one particle in 74,000 of a gas should be ionized. This was quite a large number as compared with the ionization effected at ordinary temperatures by Röntgen rays. Hence electrification by high temperatures was quite within the bounds of possibility. On the other hand, at 0 deg. Cent. the formula gave the result that in 10^{29} particles of the gas only would be electrified. Since there were only 10^{19} molecules in a cubic centimeter of gas at normal temperature and pressure, it would be necessary to take a liter of gas to include a single charged particle.

The formula was therefore consistent with the known properties of gases at ordinary room temperatures and with the conductivity of flames. If to a flame, sodium was added, a metal which required less than the 10 volts or so needed to ionize oxygen or hydrogen, the number of electrified particles was largely increased.

The effect of heat on the liberation of electricity was of very great importance also in other respects. It might, for instance, alter the nature of the carriers of the electricity. These were generally molecular aggregates consisting of a few molecules each. In some chemical actions, however, large nuclei were produced, and to this nuclear dust the particles adhered, so that the light and easily movable carrier was replaced by a great, heavy one, hard to drag along.

Dried Beer-Yeast as an Article of Food

THE necessity of husbanding the food supplies of Germany during the present war has led to a search for new sources of nutriment, from which additions to the daily fare of the nation might be obtained, and in this scrutiny the skill of the Germans in chemistry stands them in good stead. Attention has been called to the nourishment contained in straw, which would be of service if it could be extracted. Another proposition is to make use of dried beer-yeast as an ingredient to improve the flavor and dietetic results of various dishes. The surplus yeast contained in the scum and dregs of beer has not so far been put to any great use in Germany, excepting as feed for animals and as a fertilizer. There is, therefore, a large amount of raw material to work on if the suggestion, carefully elaborated in the German journal, *Umschau*, by Prof. E. Weinwurm, should be carried beyond the trial stage.

Van Leeuwenhoek, a Dutchman and the son of a brewer, was, in 1860, the first person to investigate microscopically the yeast of fermented wort, which he described as composed of small globules. It was not until the first half of the last century that it was recognized by investigators, as Latour, Schwann, and Kützing, to be a vegetable growth, developed from a single cell and propagated by germination. Meyen gave it the name of sugar fungus or *Saccharomyces*, owing to its property of fermenting a solution of sugar. The practical working of the ferment was known long before this, even though its nature was not understood. All brewed liquors in these earlier days were produced apparently, from remotest time, by self-fermentation. In reality, the yeast fungi floating in the air and the same on the surface of the malt and hops penetrated the liquid and caused the fermentation. The froth rising to the surface and consisting largely of new-generated yeast was regarded formerly as an impurity thrown out by the fermenting liquid that should be removed. In the seventeenth century the discovery was made in England that this froth could produce rapid fermentation in a wort. Consequently after this in brewing beer the yeast gained from one fermentation was used to cause another. Pasteur showed that beer-yeast was often filled with bacteria. His researches were followed by those of Hansen who discovered a process of producing pure yeast. In Hansen's process a microscopically determined culture yeast cell is propagated, under exclusion of all infection from other organisms, until a sufficient amount of pure yeast is gained to ferment a specified quantity of wort.

So much yeast is obtained during fermentation that the greater quantity of it cannot be used in the producing brewery. This surplus in Germany amounts annually to about 70 million kilogrammes and in Austria-Hungary to over 37 million kilogrammes. Some 10 million kilos of this extra quantity is taken annually for making bread-yeast. Fresh yeast from beer contains 75 per cent of water and a large amount of albumen, so that it spoils easily. This is a drawback to its sale as animal-feed, and although its large content of nitrogen and phosphoric acid make it an excellent fertilizer, the price paid for it is not in proportion to its value. Neither is the medicinal use of dried yeast sufficiently large to reduce materially the waste. Consequently, according to the writer in the *Umschau*, the only rational way of employing the surplus beer-yeast is to use it dried both as feed and food. In 1910 the research institute at Berlin for trades using fermentation took up the question and found by practical experiments on horses, sheep, hogs, and poultry, that the dried yeast was an excellent feed, when it was freed from living cells and enzymes and had the water squeezed out. It was easily digested, nourishing, and readily eaten by the animals. As a result of such investigations the yeast from beer is now dried for feed in twenty-three drying factories in Germany and five in Austria.

It was only natural after yeast had proved to be so wholesome for animals that research should be made to make it serviceable as human food, especially as it was already used for raising bread. The writer of the article gives a comparison in percentages of the chemical composition of the beer-yeast dried for food and medium fat beef. He shows that the beer-yeast prepared for food contains 54 per cent of albumen, 7 per cent of ash, 3 per cent of fat, 28 per cent of extractive substances free from nitrogen, and 8 per cent of water, while beef contains 21 per cent of albumen, 1.5 per cent of ash, 5.5 per cent of fat, no extractive matter free from nitrogen, and 72 per cent of water.

"According the statement of Prof. Cluss," continues the author, "the yeast dried for food has the following average composition: 6/8 per cent of water, 53/58 per cent of raw protein, 3 per cent of fat, 25/30 per cent of extractive matter free from nitrogen, included in which is up to 20 per cent of glycogen, and 7/9 per cent of ash. These figures show what an exceedingly valuable article of food the yeast is, and consequently how suitable to take the place of meat, and this all the more as the raw protein in its composition resembles not the albumen of vegetable food but that of meat. Along with its high content of albumen the yeast prepared for food is also marked by great digestibility, whereby the eater digests 90 per cent of it and 86 per cent of its albumen. The ratio of nutriment between yeast prepared for food and beef is as follows: 1 kilo of medium fat beef contains 1,370 calories, 1 kilo of yeast prepared for food contains 4,520 calories. Consequently 1 kilo of prepared yeast corresponds to 3.3 kilos of beef. In this yeast the purchaser obtains for 1 Mark (25 cents) 904 calories, from ordinary beef 623 calories, from fine beef 278 calories. The yeast prepared for food is therefore cheaper than ordinary beef."

The albumen of yeast contains 26 per cent of nuclein and the dried yeast about 2 per cent of lecithin, substances which hold a large amount of phosphoric acid, so that the ash is rich in phosphoric acid. The yeast prepared for food contains about 7 per cent of ash, 55 per cent of which is made up of phosphoric acid (P_2O_5). This phosphoric acid in the ash consists of 65 per cent of organically combined acid and 35 per cent of inorganic, therefore the yeast prepared for food contains 2.4 per cent of organically combined phosphoric acid. As much emphasis is laid upon organic phosphoric acid in dietetic treatment for recovery of health the yeast dried for food has proved a valuable aid in such cases. According to our author, when taken in small amounts several times a day, it stimulates the appetite (hardly a result to be desired should food fail), and in a short time has an invigorating effect upon the general health. The prepared yeast having been well tested and recognized by the German medical profession, it is now much used in the large hospitals and charitable institutions in Germany and in the feeding of wounded and convalescent soldiers.

"As regards its preparation," continues Prof. Weinwurm, "the surplus yeast is first sifted and washed, then the bitter principle of hops still existing from the fermentation of the beer is extracted. After this it is dried in a rolling machine at 125 deg. Cent. This heat suffices to destroy the vitality and enzymes of the yeast, the reverse of the process for drying yeast for medicinal purposes, where the vitality and enzymes of the yeast are preserved. The exposure to heat is so short that no essential chemical changes occur in the yeast excepting loss of water and destruction of enzymes. The scale-like yeast is ground to powder and protected against dampness both in storage and transport. The yeast has a yellowish-white color, an agreeable odor and smell."

Our author thinks the era of war the right time to try this food-yeast in the kitchens of the German nation to supplement any scantiness in the supply of meat. To do so would help the larder and prevent the economic waste of the yeast. Practical experiments in using the yeast for food were tried in 1910 at Berlin by the research institute for trades using fermentation in a manner similar to the experiments on the "poison-squad" at Washington. For four weeks 12 men belonging to the institute received daily at noon 20 grammes of the food-yeast prepared in various dishes, which they ate with hearty appetite and good results. They were all in excellent health, gained in weight, and felt fresh and full of energy during the entire experimental period.

Similar experiments were carried on at the research institute at Vienna of the brewing and malt industry, under the supervision of its director Prof. Cluss, who sought to introduce the use of yeast prepared for food in Austria. Several tests were made there with soups: one was a vegetable soup without meat, a second had 8 grammes of the yeast added instead of meat, a third was made with soup-stock instead of water, while a fourth contained both soup-stock and the yeast. The volume of each experiment was 0.25 liter, a little butter was added in every case, and the cooking was carried on for half an hour, the water lost in boiling being replaced by hot water. The result was the following: the first soup was miserable, the second proved a good average soup, while the third was decidedly better, and the best of all was the fourth in which both soup-stock and the yeast had been used.

The author also tried some experiments in his own household and found that from one fourth liter of water, 8 grammes of the food-yeast, and salt, a good-tasting soup could be made, somewhat similar in flavor to bouillon. Of his experiments in cooking vegetables he says: "Carrots prepared as a vegetable with water, salt, and the usual ingredients only, and without the food-yeast, were quite tasteless. When, though, the yeast was added, as 2½ grammes per person, the dish had a substantial, agreeable flavor. As it is customary in the house-keeping of the well-to-do to prepare vegetables with the aid of soup-stock, a similar parallel experiment was tried with and without the food-yeast in the stated quantity. Vegetables prepared with soup-stock and food-yeast had much the best flavor, being thoroughly enjoyable. No taste of the yeast was perceptible in the dishes. As the result of my own experiments I can, therefore, say: Food-yeast not only increases the nutritive value of viands but also lends them an excellent substantial flavor."

The yeast has also been used in the preparation of other kinds of food, as zwieback, cake, chocolate, cocoa, and even cheese.

This hull consists of nine circular welded sections. Upon this is built the lighter outside hull of surface torpedo-boat form.

The inner cylindrical section of the latest submarines for the Austrian navy.

The Submarine in Naval Warfare—II*

Problems of Design, Construction, and Recent Tactical Developments

By R. H. M. Robinson

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2053, Page 298, May 8, 1915

ALL of the submarine operations so far chronicled during the present European war may be said to be in the nature of naval raids, as distinguished from strictly tactical evolutions. The surface radius of even the smaller types of submarines is quite sufficient for any of the raiding operations of which we have read.

Undoubtedly the submarine proceeds on the surface to a point where previous reports indicate that the enemies' ships are, or are apt to be, then comes to the awash conditions and waits. If his quarry is sighted, he may submerge and await him, or so direct his course as to cross that of the enemy.

The fact that he was a long way from his base was, at least in the early days of the war, an undoubted benefit to the submarine, as no one suspected him of being there, but, even if they did, his invisibility when submerged and his close approach to it even on the surface make him reasonably safe, though on a long run the crew might not be luxuriously comfortable.

It is quite possible that the submarine will continue to be most heard from in this form of operation, to which its inherent qualities are well adapted. The moral influence of this hidden danger and its constant wearing away of a near or far blockading fleet or one patrolling the seas to keep them open, as the British fleet is doing in this war, is not to be underestimated in its effect on the fleet itself or the public whom the fleet represents.

I have it on very reliable authority that the Germans in the present war, in some instances, have used a fishing boat or some other surface vessel, pretending it to be a mine-layer, as a decoy.

The question of the tactical use of the submarine in groups is, however, of importance and will become increasingly so. The maximum range for successful attack of a sub marine is limited by the circle of visibility. The sea horizon, viewed from a periscope 20 feet above the surface, is just 10,000 yards. At this range the horizontal angle subtended by a 600-foot target is a little under one degree. When the periscope height is 3 feet above water the sea horizon is distant 4,000 yards, and when one foot exposed becomes 2,200 yards.

The practical difficulties of finding and then firing at specks on the horizon are so many as to compel the submarine to take advantage of her invisibility and immunity from gunfire, to push the attack to close quarters —2,000 yards or less—or, if unable to do this, then to hold fire until more favorable opportunity offers.

What I shall give you now as to submarine tactics is quoted in some part from a paper prepared by one of our best submarine officers, and may be said to have the weight of experience behind it.

Before entering into a discussion of the tactics of submarines, one should first consider the various means of communication between submarines and scouts or shore stations before sighting the enemy, and between submarines themselves after sighting the enemy.

On the surface the submarine has the following means of signalling, the order of their estimated value being as given:

Radio (day or night).
Searchlight (day).
Searchlight (night).
Shape signals (day).
Flag signals (day).
Wigwag or semaphore (day).
Very's start (night).
Wigwag torch (night).

Submerged the submarine has the submarine bell signal apparatus, and, more recently, the Fessenden oscillator, which performs the same function even more satisfactorily.

The submarine bell can be used between submarines or between submarines and tenders or shore stations, at distances varying with the attending circumstances. Under the most favorable conditions (i. e., all machinery stopped) signals may be exchanged at distances up to 8 miles with fair success. With machinery running, and under the most favorable conditions (i. e., boats running in opposite directions), signals may be exchanged at distances up to one half mile.

Of the various means of signalling, none can be used in the face of the enemy without danger of betraying the presence of the submarine group.

As the submarines of the types at present in existence have a submerged speed probably inferior to the surface speed of the enemy, and as in that case the enemy can keep out of torpedo range, it is important that no signals be sent that might give the enemy warning of the presence of submarines.

It may be wise to here give definitions to the terms "light condition," "awash condition," and "submerged condition," so that later references may be understood.

A submarine in the "light" condition has all of its water-ballast tanks empty and has its cruising bridge rigged.

A submarine in the "awash" condition has only those water-ballast tanks empty which are habitually kept full when running submerged. The fore-and-aft trimming tanks and two smaller tanks, called the auxiliary tank and adjusting tank, are filled with just enough ballast so that when the main ballast tanks are filled the boat will be immediately ready for running submerged without further adjustment of ballast. The quantity of water in the trimming tanks and in the auxiliary and adjusting tanks, in the "awash" condition, is so small, in comparison with the total ballast, that the submarine has practically the same stability and safety as when running "light." In the "awash" condition a small section of the bridge may be kept up for the lookout, and the conning-tower hatch may be kept open and the radio rigged.

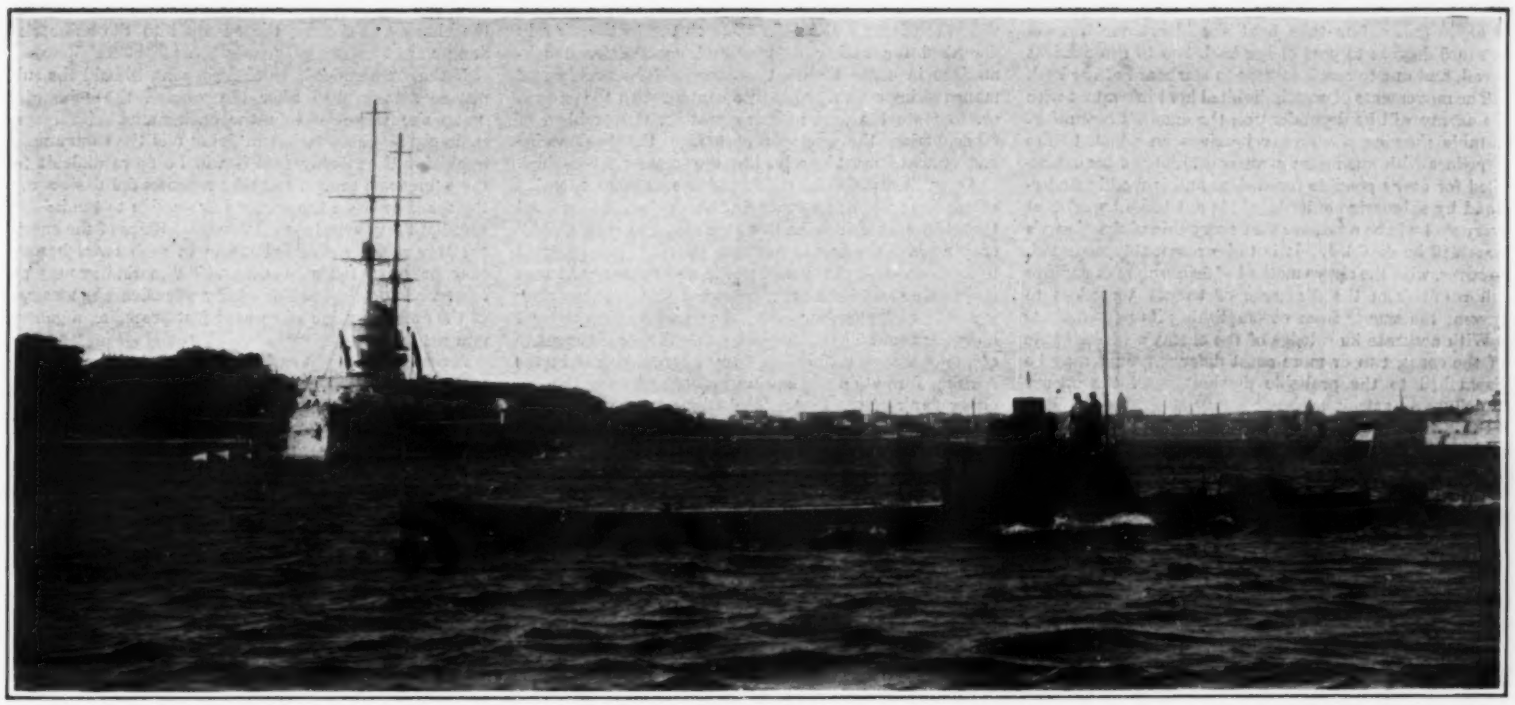
A submarine in the "submerged" condition has the ballast tanks and other tanks so filled that there still remains a small reserve of buoyancy (0 to 800 pounds) and is all ready for submerged running.

For the purpose of tactics, submarines may be divided, according to their capabilities, into three classes, viz.: harbor defence, coast defence, and sea-keeping offensive submarines.

The tactics of a group of harbor defence submarines are simple. Their limited submerged radius and speed do not enable them to operate far from the entrance of the harbor which they are protecting. The lack of reliable under-water communication makes it impossible to change plans of action, once their group is submerged, without giving the enemy a clue as to the submarine's whereabouts. Any form of under-water signalling device in use at the present time can be accurately located in direction by the enemy. The apparatus for locating the direction of submarine signals is installed on practically every modern ship. For this reason alone the detailed plans for a group of harbor defence submarines must be made explicit enough to cover in advance every plan of an attack by a determined enemy.

Each boat of a group would be assigned a certain area outside of the harbor as its zone of defence, these zones to be so selected that all approaches to the harbor

* *Journal* of the Franklin Institute.



Length, 142 feet; breadth, 12 feet 4 inches; draught, at surface, 9 feet 8 inches. Displacement: Surface, 235 tons; submerged 300 tons. Speed: Surface, 12 knots; submerged, 8.6 knots.

One of two German-built submarines for the Austrian navy.

are protected, and to be at such a distance from the point of defence that the enemy will never come within gun range.

Most of our harbors lend themselves naturally to such a method of defence by the form of the channels leading to them or by the presence of islands in the vicinity. A harbor defence group, having received warning from scouts or shore stations of the movement of the enemy off the coast, immediately proceeds to the entrance, leaving the tenders inside the harbor. Submarines anchor in the "awash" condition, radio up, in the centers of their zones, and keep a lookout for the enemy. By sub-dividing the total area outside of each harbor into small squares and using short code words to designate squares and directions, scouts in touch with the enemy can easily keep the waiting group of submarines informed as to the enemy's movements.

The waiting submarines, having been warned that in all probability the enemy will pass close to their harbor, are prepared and immediately get up their anchors and submerge as soon as smoke appears on the horizon.

With a moderate amount of their periscopes exposed, a submarine can easily see a large ship in clear weather for a distance of 7 or 8 miles. The submerged group, each boat in its zone, remains stationary until the movements of the hostile fleet are definitely ascertained. By the arrangement of the zones the enemy must pass close to one submarine; the other boats would then move over toward the enemy at such speeds and with just periscope exposure to enable them to get within torpedo range without detection. Once within torpedo range, they keep their periscopes exposed and make all speed possible to get within easy torpedo range to fire their torpedoes at that part of the enemy's formation previously assigned to them. In this last maneuver each boat would act regardless of the other boats and must take the risk of collision. On this final charge the submarine bells may be rung continuously to assist the submarines to keep clear of each other. Having fired their torpedoes, the boats submerge totally, and reload their tubes if they have spare torpedoes. During the period of reloading they may run at such depths as would enable them to pass under the enemy's vessel, or, if the depth of the water permits, they can rest on the bottom until the reload is finished, when they should return to the surface to inflict such further attack as is possible. A submarine, having exhausted her supply of torpedoes, has still a most formidable weapon in her ram. This has been proved in several instances where accidental ramming has occurred.

The harbor defence group, having exhausted its means of offence, should return to the tender, submerged, if necessary, under cover of darkness, to replenish torpedoes and storage batteries.

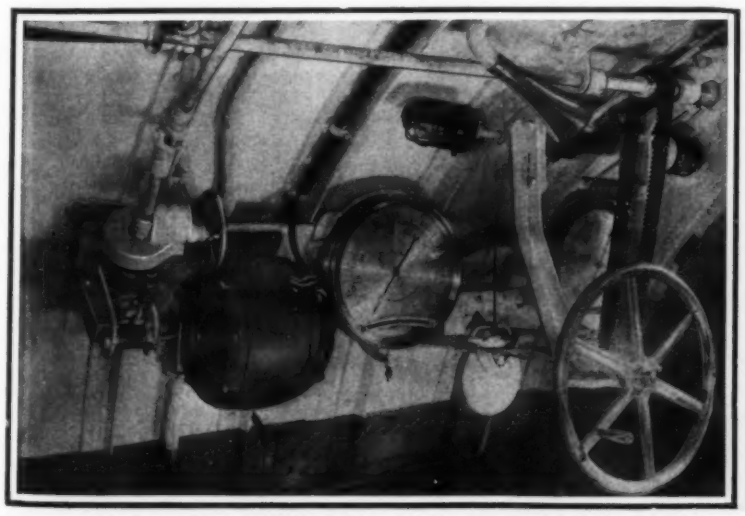
For the night defence of the harbor submarines remain on the surface in their zone, being used in this manner most effectively as surface torpedo boats. The tactics on the surface as torpedo boats are similar to the tactics employed in surface torpedo craft, though as such they are somewhat less efficient, owing to their lesser speed.

The distinction between a coast defence and a harbor defence submarine lies principally in the greater submerged and surface endurance, the greater submerged and surface speed, and the better habitability conditions of the coast defence boat, which gives it a wider range of action than its smaller sister.

It will be noted that in the defence schemes for east and west coasts submarines of the coast defence types were referred to. A coast defence group will accomplish with greater effect the same duties that are now accomplished by the harbor defence group.

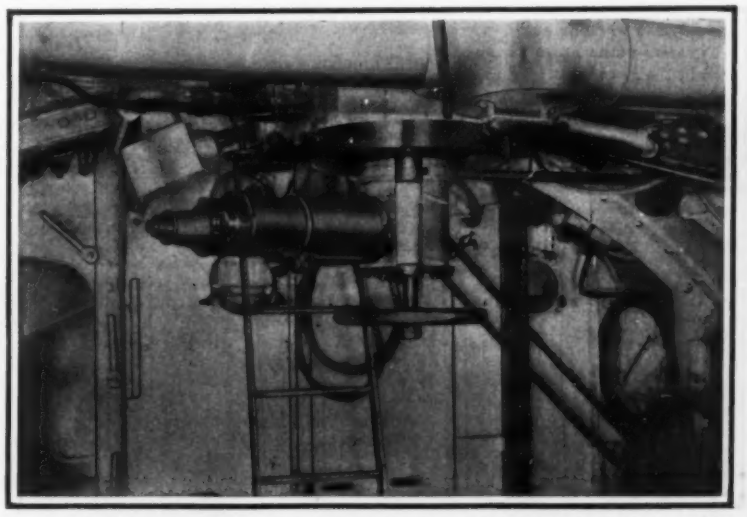
In considering the tactics of a group of "coast defence" boats it is assumed that information has been received from reliable sources, scouts or shore stations, that the enemy's fleet is approaching our coast with the evident intention of seizing a base or of landing a force. The group proceeds at its highest reliable surface speed, in column, in the "awash" condition, with radio up, to intercept or to come in contact with the enemy. The submarine, with its low hull, can easily distinguish the masts and other characteristics of a vessel when the submarine cannot be seen at all. On sighting the smoke or masts of the hostile fleet, and having approximately determined its course, the entire group immediately submerges, after rigging down the radio, and proceeds submerged at about one half mile distances, in the general direction of the enemy, at such speeds and under such general instructions as may have been previously issued by the group commander. The boats of a submarine group, submerged at one half mile distances, can easily keep clear of each other.

They should then maneuver to keep a position on either bow of the enemy's column in order to insure their getting within torpedo range before being sighted. By "torpedo range" is meant 2,000 yards. This approach must be totally submerged, with an occasional "porpoise" or periscope exposure of short duration. When within torpedo range periscopes should be exposed enough to keep an easy bearing on the enemy, and the speed increased as much as possible to arrive within easy range (between 500 and 1,000 yards) before the enemy has time for a concerted maneuver. Each submarine fires its torpedoes at the parts of the formation previously agreed upon, totally submerges, reloads as soon as possible, and



The hand-wheel operates the diving rudders used for steering in a vertical plane. In front of the wheel is a gage whose pointer shows the depth of the boat. The curved dark line below pointer is a spirit level which shows the inclination of the boat.

Diving wheel and depth pressure gage.



This shows the roof, not the floor, of the submarine interior. The horizontal eyepiece and the vertical telescope tube are rotated by means of the hand-wheel whose pinion engages an internal gear ring.

Eyepiece at bottom of periscope.

returns to the attack. Using 18-inch torpedoes capable of angle fire, a four-tube boat should set one torpedo to run 5 degrees to port of her keel, two to run straight ahead, and one to run 5 degrees to starboard of her keel.

The movements of each individual boat in contact with the enemy will be dependent on the enemy's formation. A table showing the proper bearings on which to fire torpedoes with maximum chances of hits has been compiled for every possible formation, and is readily understood by submarine officers. It is not to be hoped that every shot will be a hit, nor that every ship of the enemy's force will be disabled. It is to be reasonably expected, however, with the above method of firing, enough damage will result from the discharge of twenty torpedoes to prevent the enemy from accomplishing its purpose.

With accurate knowledge of the enemy's whereabouts off the coast, two or more coast defence groups may be dispatched to the probable destination of the enemy to deliver an attack as shown above.

Submarine groups having exhausted every means of offence, including the torpedoes and ram, should withdraw submerged at low speed or lie on the bottom, if that is possible, until nightfall, and then return to the base of supplies under cover of darkness, charging their storage batteries on their way to the base.

All attacks so far have been assumed at an enemy which is moving. Should the attacking group discover the enemy at anchor, landing troops or establishing a base, it should continue as above outlined, totally submerged, with only an occasional "porpoise" of short duration, until well within torpedo range, when the periscope should be kept exposed until the torpedos are fired at easy range at pre-arranged parts of the enemy's formation. No special difficulty should obtain in passing the line of the enemy's scouts or pickets with the submarines running totally submerged with occasional "porpoises."

After the reload of torpedoes the submarines must act absolutely independently, as it is probably impossible with the present lack of under-water signal facilities, to communicate. In all cases the chief duty and aim of the group commander must be to bring all of his group *into contact with the enemy and within torpedo range at the same time*. Having done this, it is up to the individual commanding officers to produce results.

A "sea-keeping offensive" submarine has been defined above as a submarine which can keep the sea, ready for duty, under all conditions of weather, for considerable periods. Such a submarine group could obtain its supplies from vessels of the fleet which it accompanies, and be as mobile as any unit of the fleet.

The tactics of such a submarine group after contact with the enemy will be the same as the tactics already described for harbor defence and coast defence submarines in contact with the enemy. The problem of maneuvering such a group into contact with the enemy, or, to state the case more accurately, the problem of maneuvering the enemy's fleet into the "submarine danger area," must be solved by the commander-in-chief.

As an illustration of the use of one or more offensive submarine groups accompanying a fleet, let it be assumed that the submarines have a surface speed capable of cruising with the fleet at any speed that may be required to keep up with the fleet. Let it also be assumed that the submerged speed and the radius of the submarines is about 12 knots for 1 hour, or about 8½ knots for 4 hours, or about 5 knots for 15 hours—all within the range of present-day possibilities. Suppose, also, that in the cruising formation submarine groups take position on either flank of the fleet. The submarine groups are in the "awash" condition, ready for instant use. The commander-in-chief, having received information from his scouts of the presence of the enemy, or having sighted the enemy, should immediately send his submarine groups "awash" off on a bearing previously decided upon, and then endeavor to maneuver his opponent into the area occupied by the submarines.

The submarines may remain "awash" until the enemy's smoke or masts are sighted. If our commander-in-chief possesses a superior speed, he can choose his own position, and, having patience, can eventually bring the enemy into the submarine area. In this case submarine groups should maneuver "awash" or "submerged," as is necessary to keep out of the enemy's sight, and endeavor to attack the enemy's formation as soon as possible without interfering with the movements of the commander-in-chief.

If our commander-in-chief has the inferior speed and inferior force, and if the enemy is determined to bring about an action, the problem of making him cross a submarine danger zone is greatly simplified. The appearance of several groups of submarines within or very close to the enemy just before a general gun action would undoubtedly cause the enemy to so alter his plans and formation that he would be at a temporary disadvantage. Even if all the torpedoes shot missed, the effect on the morale of the enemy would be sufficient to give our commander-in-chief a temporary advantage. Most of the important fleet actions have been fought in sight of land or close enough to shoals to cause the movements of the vessels in action to be somewhat restricted as to courses. In cases of this character the commander-in-chief can so station his submarine groups as to increase the chances of forcing the enemy into the submarine danger area.

If the commander-in-chief desires to withhold the submarine attack until after the gunfire, the submarine group should be kept in the background within easy radio signal distance, but in doing this the commander-in-chief will probably find it will be more difficult for the submarine groups to make a successful dash across the space between the engaged fleets, due to the inferior speed of the submarines submerged. Ships of the enemy that are already disabled would in such cases become easy prey for the submarines. Submarine groups accompanying a fleet are decidedly offensive weapons and of the greatest value when used just preceding a general gun action.

A ruse which might assist in forcing the enemy to keep away from certain areas and thus increase the chances of making the enemy cross the submarine danger zone would consist of having the fast scouts of the fleet drop numerous poles, properly weighted, to float upright in the water, and painted to look like a submarine periscope. These same dummy periscopes floating out of a harbor with an ebb tide or dropped outside by scouts or fishermen may greatly influence the movements of an enemy sighting them. It is extremely difficult to distinguish between dummy and real periscopes, for it is easy for a submarine to lie submerged and stationary with only a small amount of periscope showing.

Something of this kind has been successfully done in fleet maneuvers several times.

The night maneuvers of a submarine craft are the same as for surface torpedo craft, and the same tactics apply. As there is no possibility of "torching," and as the hull is so low in the water, it is extremely difficult to pick them up at night, even in the full rays of the searchlight. The maneuvers off Provincetown in the summer of 1911 demonstrated that in nearly every case the submarine could come within easy torpedo range of the enemy at night without detection. In a night attack submarines should remain in the "awash" condition, so that in case of self-preservation, or to pass through a picket line, the submarine can quickly submerge.

It may very well be that while I have been talking to you the submarine has again demonstrated its effectiveness, but whether so or not, it has already done enough to make its power felt.

A weapon to which there is no defence and no reply is one not to be lightly put aside, and no navy wanting in adequate number of submarines is complete.

Commercial Glucose and Its Uses*

A Misunderstood Product, Necessary for Certain Food Staples

By George W. Rolfe

Most well-informed people know that in the early part of the last century Kirchoff was the first to describe a sugar made by boiling starch with dilute sulphuric acid, and that this sweet, subsequently found to be other than cane-sugar was called "glucose" or "grape-sugar." Later it was termed "dextrose" when in the progress of science it became necessary to distinguish the individual from a whole family of "glucoses" which had been discovered.

Nowadays, most of us have heard of "glucose" as a commercial product of doubtful reputation. People look askance when glucose is mentioned. Confectioners and grocers make haste to deny that glucose ever appears in their products. Glucose is classed with harmful food adulterants, and has been called by pure food experts the "champion adulterant" of all. It has even been depicted in cartoons as a devil with hoofs and horns. Glucose has also been called "mucilage," the implication being that it is only fit for postage-stamps and not for human stomachs. This may be why many associate glucose with glue. The names sound alike and both are sticky, but the reasoning is like assuming that all gentlemen are gentiles. Glucose makes a rather poor adhesive, but one who is hard put for mucilage might so use it with indifferent success just as it is possible to use tapioca pudding, molasses or other sticky foods.

Turning to the advertising literature of the glucose manufacturers, we note that many eminent authorities laud glucose as most wholesome, that it is the principal sweet of fruits and one of the intermediate products of the digestion of starch in the human organism, is found in the blood,—and similar statements, all of which like the damning ones of some pure food experts are "important if true."

Notwithstanding that annually between thirty and forty million bushels of Indian corn are made into glucose, comparatively few except those engaged in the numerous industries in which glucose enters, ever see the product. The idea of the general public, professional as well as the laity, seems to be that glucose is mostly composed of grape-sugar which is made according to the Kirchoff method by boiling starch and oil of vitrol and neutralizing the mixture with chalk. Many supposedly up-to-date cyclopaedias make such statements.

Much of the ignorance concerning this important food product is due to the following facts: Pure commercial glucose is practically unknown in household cookery, and so is not sold in a package convenient for household use. While it is in multifarious food products found on the grocer's shelves it is rarely seen there in its original state. This is equally true of raw sugar. Years ago, raw open-kettle sugars were familiar to all New England housewives and were used by them in cooking. Raw sugars made by modern processes are used to some extent in England and European countries, but nowadays few of the citizens of this country, outside of the sugar producing districts, ever see raw sugars, which are sent directly to the refineries in packages weighing several hundred pounds each and in a condition not fit for domestic use. Glucose, like refined sugar, is manufactured in comparatively few factories, and these of large capacity, for the manufacture of glucose requires a large outlay of capital and consequently large output. The cheapness of the product makes its manufacture profitable only on a large scale. This is equally true of sugar.

What is commercial glucose? In general appearance it is a transparent, very viscous sirup, often practically colorless but usually of a light straw color, sweet, but with little if any other flavor. For this reason, glucose, like sugar, has been termed a "neutral sweet"—not neutral in the chemical sense—although such products are always chemically neutral within practical limits of testing—but so called because when pure they have no characteristic flavor other than sweet and will take any added flavor unchanged.

Glucose is not made by use of oil of vitrol and chalk, nor is glucose, in the ordinarily accepted sense of dextrose, its characteristic ingredient. The trade name "glucose" while well established by custom of years is no more suited to the present product than is "chloride of lime" to bleaching powder or "hyposulphite of soda" to the commercial salt sold under that name. It is true that the basic process by which glucose is made from starch is on the lines of Kirchoff's original experiment, but the methods are quite different. The "starch milk," a suspension of the granules in water, is pumped into large pressure boilers of gun metal, and is cooked for about 10 minutes with a few tenths of a per cent of hydrochloric acid (commercial muriatic acid) under a pressure of about 50 pounds of steam. The starch is not treated long enough by this process to convert it entirely into grape sugar (true glucose), only about 20 per cent being produced. There is, in fact, less of the glucose sugars, properly so called, in commercial glucose than occur as natural ingredients of cane sugar molasses, and far less than in honey, which is composed almost entirely of glucose sugars, nearly half of which is dextrose (grape sugar), this being the sugar which separates out when the honey granulates.

Commercial glucose as now made contains less than 20 per cent of true glucose sugars, the rest being a mixture of malt sugar (maltose) and dextrins, more or less in chemical combination in the approximate proportion of nine parts of maltose to seven of dextrin. In percentages of total sugars and dextrins, there are in round numbers—maltose, 45 per cent, dextrose, 20 per cent; dextrin, 35 per cent, the proportions varying somewhat in different lots.

These three carbohydrates: *dextrose*, which is a true glucose sugar; ***maltose***, belonging to the cane sugar

* From *Science Conspectus*

family, and making up nearly half of the total, and *dextrin*, a gummy ("colloidal") substance closely related to starch paste, compose over 99 per cent of the solid matter of refined commercial glucose. This composition has been found to be the most desirable for imparting to the product the properties most suited for a sirup which can be refined readily, and at the same time contain enough colloidal material to prevent its crystallizing at any concentration. This colloidal matter also renders the sirup capable of dissolving considerable amounts of cane sugar without crystallization. Such a product is peculiarly valuable in the preparation of sirups, candies, preserves, and jellies, quite apart from its use as a sweet. It also contains nearly the maximum amount of malt sugar that can be produced by such a process.

The rest of the dissolved substance of commercial glucose consists of 0.3 to 0.5 per cent of mineral matter, mostly composed of sodium chloride from the neutralization with soda of the hydrochloric acid used in the manufacture, sulphites which are added at various stages, phosphates and other salts from the natural mineral matters present in minute quantities in the starch or coming in part from the boneblack used in the refining process. There is also about 0.08 per cent of nitrogen corresponding to five or six times its weight of organic substances from the gluten left in the starch. Much of this nitrogenous matter is not gluten, but simpler organic compounds resulting from the action of the acid (used to convert the starch) on the gluten. These nitrogenous matters have much to do with the quality of the glucose, and it is on this account that they are of peculiar importance although present in minute amounts. The impurities from the gluten which are less acted upon by the acids, the "albumoses," give trouble to the candy manufacturer by causing foaming in his kettles, while this property is the joy of the brewer. Those gluten substances which are changed further by the acid, the "amino bodies," tend to make the glucose darken and also impart a flavor which though barely perceptible is disagreeable—bitter or fishy. Manufacturers used to correct the objectionable effects of these impurities by the addition of sulphites to the glucose but this was but a temporary expedient and undesirable in a food product. Glucose has been much improved in recent years by practically eliminating the effect of these impurities by more efficient purification of the starch used in its manufacture.

The glucose process does not end with the acid treatment of the starch and the neutralizing, as at this stage the dilute sirup is far from pure, containing oily matters from the corn, some undecomposed gluten and other impurities mostly in suspension. This liquor before it is concentrated to a sirup of about 80 per cent solids undergoes a refining with boneblack closely resembling that of cane sugar, the apparatus being practically identical—filtering through bags and boneblack filters—but in the case of the glucose all impurities affecting the quality of the sirup have to be removed or destroyed as there is no purification by crystallization.

Hence, glucose, like granulated sugar, is one of the purest food products in use, however pernicious the properties that may be ascribed to it.

Space does not allow a detailed description of glucose manufacture which is of great interest owing to the numerous by-products which are made, and also because while glucose is the chief in output, its manufacture is only one of many starch products carried on at the same time.

The following table, taken from an advertising circular of a manufacturer, shows in a concise way how the different parts of the corn kernel are utilized:

Parts of Corn Kernel	*Composition*	*Products*
1—Germ	Oil and Oil Cake	Corn Oil, Corn Oil Cake, Corn Oil Meal.
2—Endosperm (Body of the Corn)	Starch	Dry Starches, Dextrines, and, by conversion, Corn Sirups (glucose) and Sugars.
	Gluten	
3—Hull	Bran	—Gluten Feed.
4—Water added for steeping	Soluble Substances of Corn	

The oil is used principally for soap and for making vulcanized products used for rubber substitute. The oil-cake and meal from the cake are used as cattle feed. The gluten and bran from the starch, mixed with the soluble matters extracted by the water used to soften ("steep") the grain before grinding is made into "gluten feed" also for cattle. All these are valuable by-products for which there is a good market. The starch in a moist state, known as "mill starch," is the raw material for making the various goods which are sold under the names of "glucose" ("corn sirup"); "corn sugar" ("grape sugar"), the latter a hard product which is largely composed of dextrose, but never known in trade as "commercial glucose" and little used as a food product; "dextrins," true adhesives which are usually made by roasting starch and entirely different in characteristics from the dextrin ingredient of commercial glucose; besides numerous "dry starches" used by laundries, confectioners and in many other industries as well as for household purposes.

At present prices, commercial glucose, a sirup containing about 80 per cent of the pure carbohydrates in solution sells at about 2¼ cents per pound (26-28 cents per gallon) or at about 2.7 cents per pound of actual dissolved substance. Is its sole use that of an adulterant of better food materials as some food reformers claim? Is glucose used to adulterate our ordinary grocery sugars?

It is well known in the history of the industry that some 30 thirty years ago a Chicago concern spent some millions of dollars and much valuable time in trying to adulterate fine grained white sugars with solid grape sugar of high quality, made from the starch, but the attempt failed miserably simply because the stuff would not stay mixed and the grains "set" in a solid mass after a short time. In years gone by, glucose was also much used to mix with cheap, poor grade molasses, making a brighter, more attractive product which, so improved, could be sold at the price of higher grade molasses. This form of adulteration is so easily detected that it is rarely resorted to in these days of pure food legislation. The last case which came to the writer's notice was one of a New York molasses dealer who was heavily fined for having a few per cent of commercial glucose in his molasses, although his defense was a plausible one—that some glucose was accidently left in the barrel, old glucose barrels being much used for tropical molasses shipments.

Glucose is now used in a legitimate manner to mix with cane-sugar sirup in the proportion of 85 per cent of glucose to 15 per cent of sirup, a little salt and sometimes vanillin being added to improve the flavor. The cane-sugar sirup is usually refinery molasses ("barrel sirup") which imparts the principal flavor. These mixed sirups are sold openly as glucose or "corn sirups" and as their flavor is superior to the original molasses there seems to be no reason why they are not wholesome food products for legitimate trade, even though some people there are who prefer the flavor of the sirups made from the natural cane juices and are willing to pay the higher price for such. Certainly, such glucose sirups are preferable to the average grocery molasses either from the standpoint of the epicure or the sanitarian.

Commercial glucose is used in large quantities in the manufacture of cheap jams and preserves. Apple cores and skins from fruit in its preparation for evaporation or preserving are the basis for most cheap jellies; the pectin substance and juice being extracted by the usual processes of jelly making and mixed with glucose and sugar, forms a jelly material to which other fruits are added. The law requires such jellies to be plainly described on the label so that the consumer is informed that he is using a jelly made of apple and glucose with a fruit flavoring, and is at perfect liberty to buy the pure glucose-free fruit product if he so prefers. What interests the public is: Are these cheap jellies unwholesome, or is there other reasons why the man with the slim pocketbook should not buy them? This question is quite apart from whether they contain glucose or not, but deals with the soundness and wholesomeness of the ingredients used and the cleanliness of their preparation.

By far the largest amount of glucose is consumed in the manufacture of candy, the peculiar properties of this sirup making it especially valuable in this industry, as has been explained. The requisite for most candy is that it should not "grain" (crystallize), and glucose, owing to its colloidal nature, is the most effective and wholesome substance to prevent this. The popular impression that glucose is used in candy-making because it is a cheap substitute for sugar and that its sole function is to give sweetness is only approximately correct.

How sweet is glucose relative to cane sugar? Determinations of the sweetness of a saccharine product are very unsatisfactory, owing to personal equation and also to the influence of the other mixed ingredients and even the physical condition of the substance tested.

Granulated sugar tastes sweet. Powder it in a mortar and it will taste less sweet. Owing to this fact it is hard to convince some people that powdered sugar is not adulterated, although this practice, easily detected, is practically unknown at present. A quarter of a grain of quinine mixed into a pound of granulated sugar is said to make it taste sweeter. Common salt in small quantities will improve the sweetness of cake and other sweet foods, as all cooks know. Raw sugars, even when they contain negligible quantities of the sweeter mother-sirups, taste distinctly sweeter than granulated sugar although their actual sugar content is less. This is due to the salts and extractive matter in the raw product, and it is why many cooks sigh for the old-fashioned open kettle sugar and even prefer the refiners' imitation goods to granulated in making their apple pies.

Relative tests of the sweetness of cane sugar and glucose (*dextrose*) have been made by dilution experiments on the pure sugars, but as far as the writer knows, no relative tests of the sweetness of commercial glucose as now made have been published. Taking this value to be 0.5 for the solids in glucose, sugar at 5 cents is cheaper as a sweetener than glucose.

As a matter of fact, very little candy is made with glucose as the only sweet. Usually, candy contains 60 per cent or more of cane sugar, the sweetening of the glucose being of much less importance than the other properties it imparts to the mixture.

It seems reasonable to infer that commercial glucose, rather than being a serious competitor of cane sugar, has really increased the consumption of the latter, especially in candies. Because of the great advantages from the use of glucose in candy-making, the industry has had an impetus which has greatly increased sugar consumption.

The relative wholesomeness of candies made from glucose and those made from cane sugar has never been decided, and may never be. The dextrins of "glucose" as now manufactured are in great part in combination with the malt sugar and seem in every way identical with the malto-dextrins obtained by the action of malt on starch, and are digested more in the intestines than in the stomach as compared with pure sugar candies. Whether this is an advantage or not, the physiologists must decide.

Glucose is extensively used in industries not making food products. It is used in cheap soaps, for "filling" leather and tanning extracts, and as many of its uses in such industries are apparently for adulteration, such practices have no doubt added to its reputation as the "champion adulterant." As was pointed out in an article in a previous number of *Science Conspectus*, No. 2, 1913, on the industrial uses of sugar, the highly respectable beet sugar of 99 per cent purity is used in Europe for precisely the same purposes, the choice between sugar and glucose as a "filler" being merely a matter of price. Cane sugar has also been used extensively to "fill" coal-tar dyes and adulterate chocolate without having its respectability seriously impugned.

In view of the undoubted commercial importance of glucose as a food product it would seem as if its value in dietetics and food economics, as well as its relative wholesomeness, ought to be studied in the light of a proper knowledge of its special characteristics. To call glucose "mucilage," or to ascribe to it properties of a dextrose solution is either ignorant or dishonest. As far as the use of glucose as an adulterant is concerned, it is the function of the Pure Food Laws to protect the public from these practices, and such obviously are quite apart from the legitimate and open use of glucose, sugar or any other cheap and wholesome food product as a satisfactory substitute for more expensive ingredients, and the propriety of such a substitute always will be its suitability for the purpose and its cost.

If legislation is appropriate for forbidding the extravagant claims of manufacturers and dealers as to the superiority of their food products, why not legislation to prevent irresponsible statements of "pure food" authorities which are condemnatory? Certainly, the one is fully as important for the public interest as the other.

Protecting Steam Boilers

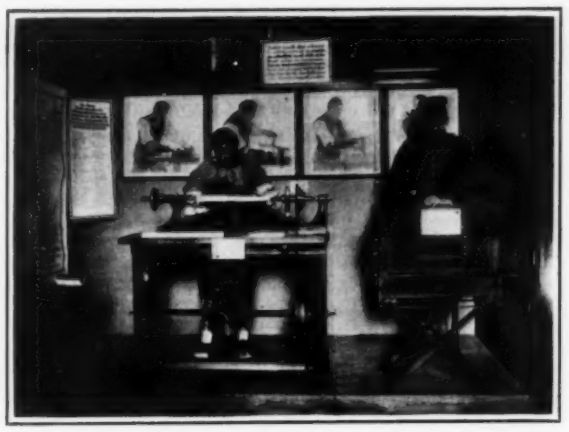
In large steam power plants it is very desirable to keep a careful and constant watch on the feed water to guard against the entry into the boilers of any contaminating substance that might cause scale or irregularity of working, for it has been found that prevention in such cases is much cheaper than cures, both in regard to labor and in loss from interrupted operation. In one of the large electric generating stations in New York salt water is used for cooling the condensers, and to insure that none of it gains access to the boilers through a suddenly developing leak the condensed water is tested every hour by titration with nitrate of silver. This frequent testing is necessary because, in a plant of the size in question, it would be but a matter of a short time for a comparatively small leak to make a decidedly injurious addition to the feed water. Besides this test, the contents of the boilers themselves is also tested once a day as a check, but the principle dependence is placed on the scrutiny of the condenser water.

Luxembourg Bridge

The Adolph Bridge at Luxembourg is constructed on the designs of M. Séjourné, a prominent Paris engineer. His idea is to reduce the amount of masonry for a given width of bridge, for instance in a single-arch span, and to build two arches side by side with a space between them. Upon the pair of arches is laid a reinforced concrete floor. Span of the Luxembourg bridge is about 280 feet, and the platform is 135 feet above the level of the stream. Width, 52 feet. The structure cost $300,000, which is $50,000 less than the cost of a full-arch bridge of the same kind.

French surgeon inspecting his fellow prisoners in Germany.

A 42-centimeter shell.



Cripples working at trades by aid of artificial limbs.

An Exposition of Military Sanitation

Showing How the Sick and Wounded Are Cared for in This War

By Dr. Alfred Gradenwitz

An efficient sanitary service is a necessity to armies for humanitarian as well as practical reasons. It is, in fact, of the highest importance that patients should, if possible, be fitted to return to the firing line as soon as practicable, while those unable to resume fighting should at least be in a position to take up their pursuits at home, and not become a burden on the state. Humanitarian reasons are, of course, also taken into consideration, and private as well as public charity find ample scope for their patriotic endeavors in the interests of the immediate victims of war.

While strategy has, of recent years, undergone a profound revolution, sanitation has also made enormous strides, availing itself of all the latest achievements of medical and physical science as well as engineering.

The vast field of sanitation in all its various phases, as it is practised in the present war, is surveyed in a very attractive way by the Exposition of Military Sanitation being held at Berlin. This instructive show comprises not only all classes of sanitary equipment, models of means of conveyance and sanitary buildings, but a model about 12 meters long which represents a several days fight for a fortified town, thus affording an opportunity of illustrating in all its details the work of the sanitary corps in actual battle.

On entering the exposition we are at first struck by the model of a ship hospital, which, in full size, represents all the arrangements usual on war ships. Parts from the ships of the German navy have been used in mounting this model, the medical instruments and other utensils, as well as the chemist's shop, being likewise derived from the navy stores. The model illustrates the arrangements provided for peace and war use, showing, for instance, how the wounded are transported on staircases and through hatches, in a special hammock developed during many years' trials in time of peace. The dressing stations, equipped with all surgical implements are, of course, installed in those parts of the ships which are least exposed to the enemy's fire; the operating tables are provided with special damping devices allowing for the ship's movements. When an engagement is over, the remaining hospital rooms are, of course, available. Movable berths, adapted to the rolling and pitching of the ship, are used. Any seriously wounded are, however, at the earliest possible moment, transferred to some hospital ship or to a naval hospital in a harbor town.

Adjoining this section is the most important and extensive department of the exposition, where the sanitary service of the German army is illustrated in all its details by means of models and actual equipment as used in current practice.

As in all other modern armies, the sanitary service begins with the dressing package which every soldier carries about him, and which enables him at any time to apply a first dressing to himself or some wounded comrade. Whenever any further care is required the ambulance staff take charge of the patient. It would be too long to describe the whole mechanism constantly at work in receiving and evacuating patients. The most important phases of this service are, however, enumerated in the following:

Every large detachment, e. g., every infantry battalion, has a special staff and some material of its own, which is taken close to the firing line, and installed in a sheltered position. Such troops as are equipped with vehicles, e. g., the artillery, do not require any sanitary cars. Apart from these arrangements destined for rendering first help, each army corps includes three ambulance companies distributed in accordance with actual requirements, and which carry not only more abundant sanitary material, but a certain number of ambulance cars, as well as a supplies car and field-kitchen. The work of these ambulance companies is centered on a main dressing station, whence the men search the battle-field methodically. However, the wounded are, at the earliest possible moment, evacuated from these dressing stations; those only slightly wounded will often be able immediately to return to their division, while the balance are taken either to a convalescent camp or to a field hospital, of which each army corps has twelve. It being desirable to get these hospitals in readiness for any further work that may turn up at the earliest possible moment, a point is made of clearing them as soon as possible, patients being returned to the front, if their condition permit, or turned over to one of the larger hospitals in the line of communications or base. German practice in this war has so far been to send home as many patients as possible, to be treated either in some large hospital or in their families. This, in fact, not only prevents the hospitals near the theater of operations from becoming overcrowded, but exerts a most beneficial effect on the *morale* of the men.

Apart from stationary hospitals portable barracks are used to a large extent, in fact wherever no adequate buildings are available. These barracks, which are fully represented at the exposition, are readily installed, taken apart and conveyed to any place where their services may be needed without the aid of skilled workmen. Patients suffering from contagious disease are housed in special hospitals.

The arrangements used in transporting wounded and sick are likewise illustrated by actual outfits as well as models. While being used occasionally for the transport of sanitary material, X-ray outfits, etc., automobiles play a much more important part as a means of conveyance for invalids. Motor buses converted into ambulance cars are shown side by side with all the various systems of motor ambulances designed of late years.

Railroads and ships are, of course, mainly used in conveying the wounded from the theater of operations and the base to their respective home districts; wherever required, the German corps of engineers will install at short notice railroads for military use and for large scale invalid transports. Apart from improvised ambulance wagons, the arrangement of various systems of ambulance trains proper is illustrated on actual specimens and models. The distinctive feature of these systems generally is the elastic suspension of the beds.

The fighting of disease and epidemics in war is the object of another department of the exposition. When it is considered that contagious disease has, in most wars, wrought even heavier havoc among the armies than the projectiles of the enemy, the importance of this subject will be readily understood. Foremost among the means used in this connection should be mentioned the various sera, which have lately been developed to such importance, especially in the case of diphtheria, dysentery, meningitis, and quite recently, tetanus. The manufacture of these sera (mostly derived from immunized horses) is illustrated in two pictures, while a third shows the way of using meningitis serum. Prophylactic inoculation, not only against smallpox, but against cholera and typhoid fever—according to new processes successfully employed in the present war—is likewise illustrated by photographs and statistic tables. The divers processes of disinfection, of elementary importance in the fight with epidemics, are, of course, dealt with in great detail.

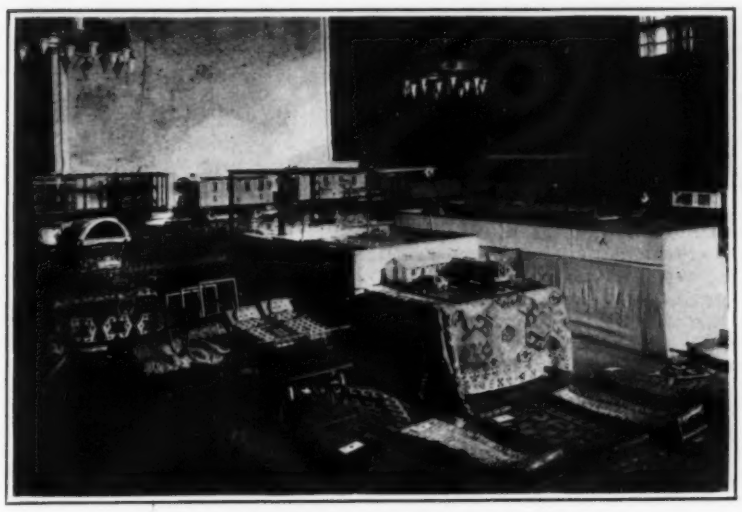
Realizing that tuberculosis is a factor of paramount importance in the state of health of a nation, and, accordingly, its aptness for military service, the army and navy have, for many years, bestowed especial attention on this disease. A special section of the department last named is therefore given up to the means of fighting tuberculosis and statistical returns on their effectiveness. Sufferers from tuberculosis are, of course, kept away, as far as possible, from the army and navy. Whenever the disease develops in course of service, patients are discharged and are, if necessary, placed in some sanatorium.

From this department we enter that given up to X-ray work. While being indispensable in general medical and surgical practice, X-rays play an especially important part in military surgery. In fact, even the smallest German army or navy hospital comprises a complete X-ray outfit, used not only in discovering and locating foreign objects but in watching the healing process of fractured limbs and allowing any displacement of the fragments to be effectually prevented. A number of special apparatus, transportable and portable outfits, etc., are on show.

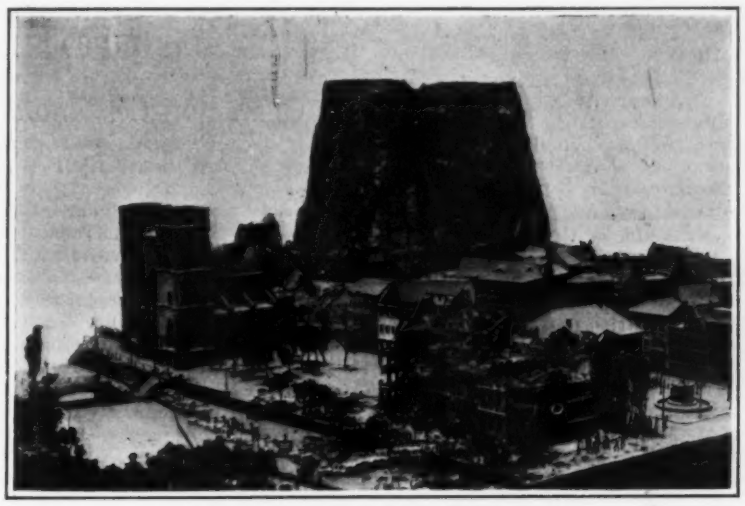
Another section is devoted to the dentist's tasks in war. In the modern fortification war, the number of wounds of the head and, especially injured jaws, is particularly great, thus affording ample scope for dentist's work. On the other hand, there is the prophylactic treatment of otherwise healthy soldiers, a man suffering from toothache being practically useless from a military point of view, while the presence of lesions in or near the jaws, in the event of a wound, greatly increases the risk of infection. All these tasks are illustrated in a striking manner. We see the dentist at work in his improvised consulting room, with a most practical portable outfit, special kinds of dressing being demonstrated on models. The use of X-rays for the special purposes of the dentist is likewise shown.

We now enter the department illustrating the technicalities of nursing, which art has, especially of late years, undergone such a rapid development. The extensive material is distributed in accordance with scientific principles in ten cabins arranged alongside the walls. We thus acquaint ourselves with the means of bedding patients, the principles governing the dress of invalids and nurses, and the arrangements used to keep patients clean. In a fourth cabin, there are technical arrangements for the feeding of patients, and in a fifth one, those for administering medicine. The various means of opening a patient's bowels are found in a cabin of their own, as are the methods for warming and cooling patients. Apparatus for the active and passive motion of the sick and wounded and means of instruction in the technicalities of nursing are likewise on show. There is finally a special exhibition of all sorts of methods and devices for amusing and occupying patients.

Another most instructive department is that devoted to the care for cripples, where all the various means of preventing wounded limbs from becoming crippled are shown, both orthopædical apparatus and operative processes. The training of cripples for manual work is likewise illustrated, thus showing the solution of an urgent social problem. Two cripples are represented by life-size figures, one of whom, according to the old practices, plays the barrel-organ, whereas the other, an extreme case, though having lost both arms and both



Various methods of transporting the wounded.



Model showing effects of a bombardment.

legs, worked merrily away on the lathe. How this apparent miracle is wrought, what arrangements serve as artificial limbs and by what means the cripple is enabled to handle any tool with his mulitated arms, is fully illustrated. The German authorities are confident that all war cripples will be able to work at some craft, and not be dependent on charity.

Voluntary sanitation in war time—the organization and work of the Red Cross Societies and orders of knighthood—is represented in a mainly statistical department; and the last section allows the history of military sanitation from antiquity, through the middle ages, up to modern times to be studied from a large collection of historical objects and pictures.

Modern Theories of Gravitation*

UNIVERSAL gravitation still remains as mysterious as it was two centuries ago. Electrical, magnetic, and other physical forces are dependent on the nature of matter, and they can be subjected to influences that modify their intensity and effects, but universal gravitation, intangible and immutable, defies the art of the experimenter. The weight of a body does not change when the matter of which it is composed passes from one physical state to another, or even when it undergoes the most profound chemical alteration, and the acceleration of all bodies falling in a vacuum is exactly the same. No modification of the mutual attraction of two bodies produced by the interposition of a third body has ever been detected, and it must be admitted that gravitation can pass through the whole earth without being appreciably weakened. In a word, nothing in gravitation can be altered.

Electrical and magnetic forces exhibit a considerable analogy with the force of gravity. The attractions and repulsions of electrified bodies and magnetic poles obey Newton's law, and the same equations apply to these and to gravitational phenomena. The potential of gravitation and the electrostatic potential are defined in the same manner, and the equations of Laplace and Poisson apply to both. But can the analogy be carried further? In electricity an important rôle is played by the medium in which electromagnetic effects are propagated with the velocity of light. Is gravitation produced in like manner and propagated through the ether with a finite velocity, perhaps equal to that of light?

This question is of fundamental importance, for equal velocities of propagation of gravitational and electromagnetic effects would suggest a close relation between the two phenomena.

Several years ago H. A. Lorentz proposed an electromagnetic theory of gravitation, based on then recent discoveries concerning electrons. The fundamental equations of this theory contain the velocities of electrified particles, relatively to the ether. So long as two electrons are at rest their mutual action is given by Coulomb's law, but their movement introduces a modification which depends on the ratios of their velocities to ttha of lihgt.

The new law of attraction differs from Newton's law by the inclusion of terms which depend on the motions of the bodies and can be developed in series of ascending powers of $\frac{v_1}{V}$ and $\frac{v_2}{V}$, in which v_1 and v_2 denote the velocities of the two bodies, and V denotes the velocity of light. The formulas obtained contain no terms of the first degree, and the terms of degrees higher than the second are so small that it will suffice to consider the terms of the second degree, i. e., terms containing

$$\left(\frac{v_1}{V}\right)^2 \text{ and } \left(\frac{v_2}{V}\right)^2$$

An important question is now presented. Do observed astronomical phenomena permit us thus to modify Newton's law? The ratio $\frac{v}{V}$ is about 1-10,000 for the earth, 1/8,500 for Venus, and 1/6,200 for Mercury. The effect of the terms which contain the squares of such small fractions is always exceedingly small and very difficult to detect. The longitude of the perihelion of Mercury is found to be subject to a secular variation which does not appear to be attributable to the attraction of the other planets. This is one of the rare phenomena which show discordance with Newton's law. Lorentz computes the secular motion of the perihelion at 4 seconds, which is about one tenth of the observed discrepancy. The motion may be due, however, to the attraction of a swarm of small bodies surrounding the sun. The existence of such a swarm has sometimes been assumed in order to account for the zodiacal light.

Lorentz abandoned his theory after the publication, in 1906, of Einstein's principle of relativity, with which the Lorentz theory of gravitation disagrees, in retaining the old laws of mechanics, and also in introducing the movement of the entire solar system relatively to the ether.

The momentum, or quantity of motion, of a body is usually defined as the product of its mass multiplied by its velocity, but in "relativist" mechanics this product, mv, is divided by $\sqrt{1-\frac{v^2}{V^2}}$, and the kinetic energy is mV^2 divided by the same factor. In these expressions v denotes the velocity of the body, V the velocity of light, and m may be called the "constant mass." It is often advantageous to introduce a "variable mass" M, obtained by dividing m by the above-mentioned factor. The momentum then becomes Mv, and the energy MV^2, plus a constant.

A relativist theory of gravitation has been developed by Poincaré and Minkowski. If we know the force exerted by a motionless body upon a moving body, the principle of relativity enables us to calculate the force acting on each body when both are in motion, and consequently to determine the motion of each body by means of the equations of relativist mechanics. The problem is not quite determinate, because the principle tells us nothing of the effect of a body's own motion on the force exerted on it by a body at rest. If we take the mutual action of two electrons as a model, we are led to conclude that the force thus defined is independent of the velocity and reduces to the Newtonian attraction. On this hypothesis De Sitter has computed the variations in the elements of planetary orbits and has found 7 seconds for the secular motion of the perihelion of Mercury. This result is due entirely to the new definition of momentum, and involves no modification of Newton's law, so far as the force acting on the planet is concerned.

Einstein's theory of gravitation differs from the preceding theory in that it leads to a force differing slightly from the Newtonian attraction, even for a planet at rest. Its point of departure is a very remarkable deduction from the principle of relativity. As the kinetic energy is equal to MV^2, plus a constant, it follows that every variation in the kinetic energy involves a variation in M, the "variable mass," which may be expressed by saying that energy itself possesses or represents a certain mass. Hence the weight, if it is proportional to the mass, is likewise increased by any increase in the kinetic energy, and all kinetic energy (that of radiation, for example) possesses weight.

Also, to say that a material point is acted on by a force is equivalent to saying that its momentum is changing. As the motion of momentum has been extended to electromagnetic waves, it follows from the preceding considerations that the velocity of light is not the same at every point of the field of gravitation.

If a body acquires a velocity u in falling from one point to another under the influence of gravitation, the velocities of light at those two points should differ, according to Einstein, by about $\frac{u^2}{2V}$.

This is Einstein's theory of gravitation in its first form. His incessant efforts to improve it have resulted in the admirable theory which he has recently published, in collaboration with Grossmann.

In this improved and very complex theory, a field of gravitation is characterized, not by a single potential, but by ten parameters which depend, in general, on the geometrical co-ordinates and the time, and whose variations determine all the effects of gravitation. The application of the theory, however, is simplified by the fact that many of the terms are too small to produce observable effects. One of the ten parameters is predominant, taking the place of the single potential of the old theory and the variable velocity of light of the provisional theory.

The improved theory leads to the conclusion that gravitation is propagated with the velocity with which light moves in the absence of a gravitational field. The expression for the attraction exerted upon a planet by the sun contains, in addition to the principal terms corresponding to Newton's law, terms of the second order of magnitude that depend on the planet's motion.

Einstein has pointed out some results of the theory that may, perhaps, make it possible to observe almost directly the variation of luminous velocity in a field of gravitation.

First: A luminous pencil should be curved by the influence of weight. The change of direction would be quite insensible to the terrestrial, but very much greater in the solar field. Einstein calculates that a ray of light coming from a star and grazing the sun's surface would be bent inward by 0.83 second, increasing by that amount the apparent angular distance of the star from the sun's limb. This effect might possibly be observed in a total solar eclipse.

Second: If light coming from two sources of different heights is examined with the same spectroscope, the spectral lines of the higher source should be a little nearer the violet than the corresponding lines of the lower source. This effect also is absolutely inappreciable in the terrestrial, but not in the solar field. For two similar molecules, situated respectively on the sun's surface and at the earth's distance from the sun, the difference is about one hundredth of an Angstrom unit. Hence, the Fraunhofer lines of the solar spectrum should be nearer the red, by this amount, than the corresponding lines of a terrestrial source. Displacements of this order of magnitude have actually been observed. They have been attributed to effects of pressure and movement, but they may be due to the cause indicated by Einstein.

The only important difference between the electromagnetic and gravitational fields is that the former is determined at every point by six parameters (the components of the electric and the magnetic force), and the latter by ten. In each case the field is the seat of momentum and energy which it can impart to, or receive from, matter. It is quite possible to regard both fields with all of their properties as consisting of different modifications in the internal condition of the same ether.

* From an article in *Revue des Sciences*, based on an article by Lorentz, in *Scientia*.

Salts Colored by Cathode Rays*

Their Peculiar Characteristics, and an Endeavor to Explain the Phenomenon

By Prof. E. Goldstein

If cathode rays fall on certain salts—for example, common salt, or chloride of potassium, or potassium bromide—vivid colors are produced immediately on these salts.[1] Thus common salt becomes yellow-brown (like amber), potassium chloride turns into a beautiful violet, potassium bromide becomes a deep blue color quite like copper sulphate. Here you see a specimen of common salt transformed in this way on the surface of the single crystals into a yellow-brown substance. I show also sodium fluoride, which takes a fine rosy color.

The colors so acquired in a very small fraction of a second may be preserved for a long time, even for many years, if the colored substances are kept in the dark and at low temperatures. But in the daylight, and also under heat, the colors will gradually disappear until the original white condition is reached again.

The colors of different salts are sensitive to heating in a very different degree. I could show you the yellow sodium chloride, prepared some months ago in Europe, but I cannot show you here the violet KCl and the blue KBr, because these colors, even in the dark, do not stand the heat of the equator. The same salt, if dissolved, may keep very different colors, according to the medium in which it has been dissolved, even when the pure medium itself cannot be colored at all by cathode rays. I am speaking of *solid solutions*, produced by fusing a small quantity, for instance, of common salt or of certain other alkali salts, together with a great mass of a salt which remains itself colorless in the cathode rays, as, for example, the pure potassium sulphate. Lithium chloride acquires a bright yellow color in the cathode rays; but if dissolved in potassium sulphate a lilac hue is produced, as you may see in this specimen. Likewise the pure carbonate of potassium acquires a reddish tint, but after dissolving it in the potassium sulphate it becomes a vivid *green* in the cathode rays, as you see here.

Very small admixtures are sufficient to produce intense colors. So 1/25,000 of carbonate will produce the green color in the potassium sulphate; even 1/100,000 gives a marked color, and an amount of certain admixtures, which I estimated as 1/1,000,000 only, may produce a slight but quite perceptible coloration in some salts. So if you work with potassium sulphate which you obtain from chemical factories guaranteed as chemically pure, you may observe a set of different colors in these preparations under the cathode rays, by which you will detect the nature of the different small admixtures which adhere to the pretended pure preparations of the different factories. In this way a new analytical proof, much more sensitive than the ordinary chemical methods, is obtained, and impurities may be detected even when a certain specimen of salt contains more than a single impurity, because the colors produced by different admixtures generally disappear with different speed in the daylight or under rise of temperature. For instance, the ordinary potassium sulphate turns to a dark gray with a single greenish tint at first. After a short while the very sensitive gray will disappear, simply under the ordinary temperature of the laboratory room, and a vivid green comes out. The gray hue indicates a very small amount of sodium chloride, 1/100,000 or so, and the remaining green indicates the admixture of a carbonate. Here are some preparations of potassium sulphate, each containing a single small admixture (K_2CO_3, Li_2CO_3, LiCl, KCl, KBr). You will notice how different are the colors of the originally white substances, varying from green to bluish-gray, ash-gray, grayish-blue, and violet.

By fractional crystallization one may finally get a really pure preparation of potassium sulphate, which is no longer colored by cathode rays (or only in a very slight degree, indicating minimal traces of sodium chloride). But there are other preparations which, so far as I know, cannot be acquired in pure conditions by any means, not even by fractional crystallization. I never came across a pure sodium sulphate—the purity exists only on the manufacturers' labels. Even the best preparations of this salt contain an amount of sodium carbonate which up to the present cannot be separated from it, not even by frequent fractional crystallization. The color produced by the small admixture, which always remains, is a very marked ash-gray. By an intentional further addition of sodium carbonate the color becomes nearly black.

The question arises: What may be the cause of these colorations in pure salts and also in solid solutions of them? Shortly after the colors of the alkali salts had been discovered, an explanation was given,[2] according to which the phenomenon mainly consists in a chemical reduction. For instance, in the case of potassium chloride the chlorine would be set free, while the remaining potassium is dissolved in the unaltered main quantity of the salt, coloring it at the same time. And it seemed a convincing proof for this theory when Geisel[3] and also Kreutz, simply by heating rock salt in the vapors of sodium or of potassium, produced colors in this rock salt quite similar to those produced by cathode rays. It seemed that the problem was settled finally. However, it was soon discovered that the colored Giesel salts, although they look to the eye quite like the cathode-ray salts, in all other respects behave quite differently. For instance:

(1) The cathode-ray salts, as I mentioned before, are very sensitive to daylight: after an exposure to diffuse daylight of a few minutes, or in some salts even of several seconds only, the coloration diminishes, while the Giesel salts remain unaltered even when they are kept in full sunshine for days or even weeks.

(2) The cathode-ray salts, if dissolved in distilled water, show absolute neutral reaction; the Giesel salts are strongly alkaline.

(3) The cathode-ray salts give very marked photo-electric effects (as Elster and Geitel[4] observed); the Giesel salts are quite ineffective.

(4) In certain circumstances, which will be mentioned further on, the cathode-ray salts may emit a phosphorescent light, the Giesel salts none at all. Therefore the question arose again, Whether there is not a marked internal difference between the cathode-ray salts and the Giesel salts, and what is the nature of the latter?

I have succeeded in settling this question, having produced salts *by cathode rays*, the behavior of which is in every respect *absolutely identical with that of the Giesel salts*. You may produce such substances if you allow the cathode rays to fall on the original salts not for a short moment only, but for a somewhat prolonged time, *until the salts are strongly heated*. Produced in this way the salts will keep colors; but the substances colored in this way are *not* sensitive to light; they show no photo-electric effect; they give *strong alkaline* reaction, and they are not suited for phosphorescence—all like the Giesel salts. It is quite sure, and you may test it also directly by spectroscopic proof, that in this case, if, for instance, you have worked on sodium chloride, *the chlorine is set free*. Then, of course, an amount of free sodium is left, which dissolves itself in a deeper layer of unaltered sodium chloride, to which the cathode rays could not penetrate. I call these non-sensitive colors *the after-colors of the second class*, while the ordinary sensitive after-colors, produced in a short time on cool salts, are called after-colors of the first class.

Now, if the after-colors of the second class are identical with those of the Giesel salts, then, of course, the very different substances of the first class cannot be also identical with the Giesel salts. Therefore the question arises anew, What is the nature of the first-class after-colors?

One observes with regard to solid solutions that the first-class colors depend not only upon the *metal* contained in the small admixture, but they vary greatly, for instance, in the case of the admixture consisting of potassium chloride or bromide or iodide. This indicates that the metals alone do not cause the after-colors. It becomes much more clear when we expose some ammonium salts to the cathode rays. (The ammonium salts are cooled by liquid air in the discharge-tube to prevent their evaporation.) Then you get strongly marked after-colors likewise; for instance, ammonium chloride becomes yellow-greenish, the bromide becomes yellow-brown, the iodide becomes brown, and the fluoride a deep blue. In the daylight these colors are gradually destroyed, quite like other after-colors of the first class. The colors themselves—yellow-greenish for the chloride, yellow-brown for the bromide, and so on—induce us to presume that the after-colors in this case are produced by the haloids, and not by the hypothetical ammonium radicle. This presumption becomes a strong conviction when we observe that also a great number of organic preparations which contain no metal at all (and not any metal-like radicle) acquire marked after-colors of the first class in the cathode rays also. (The part of the discharge-tube which contains the organic substances is cooled by liquid air.)

Then you may observe that solid acetic acid ($C_2H_4O_2$) remains quite colorless in the cathode rays; but if you substitute a hydrogen atom by chlorine, the substance thus produced (the monochloro-acetic acid) acquires a marked yellow-green after-color. If you introduce an atom of bromine instead of chlorine, you get $C_2H_3BrO_2$, and the after-color is of a marked yellow. Bromoform ($CHBr_3$) turns into the color of loam, and chloral (C_2HCl_3O) becomes a deep yellow. In this way we see that not only salts, but likewise substituted acids, substituted hydrocarbons, and substituted aldehydes acquire after-colors if they contain any haloid.

Now, it seems highly improbable that in the case of alkali salts the electro-positive component is absorbed only (producing the after-color), and that, on the other hand, in the ammonium salts and in the organic substances the electro-negative component is efficient only. The most probable inference is that in each case *both* components remain and that both are efficient, but that under the same conditions the haloids produce a slighter color than the metals, so that in the case of the salts the haloid color is overwhelmed by the metal color.

Therefore we are compelled to suppose that we have not to deal with a decomposition in the ordinary form, by which the different components are finally separated from each other and at least one of them is set entirely free, but that the components detained by absorption remain at a quite short distance from each other, so that they may easily meet again. I realize that, for instance, in the case of sodium chloride, at every point of the colored layer there is an atom (or perhaps a molecule) of chlorine and an atom (or a molecule) of sodium; but they cannot combine, because they are fixed by absorption and distended from each other by the absorptive power, which in this case surpasses the chemical affinity. But the absorptive power may be weakened by heating and the chemical affinity or the amplitude of the molecular vibrations may be strengthened by the energy of daylight.

If we grant these assumptions, it is immediately evident why the reaction of all dissolved color substances of the first class is a neutral one, for the two components may combine again and re-establish the original substance. The other special qualities of the first-class colors, and especially their differences from the Giesel salts, which contain the electro-positive component only, may be deduced likewise from this retention of both components and their opportunity of meeting each other again when the absorptive power is weakened or the chemical affinity is strengthened. Now, the two components in the colored substances being distended in some degree, I propose for this special condition of matter the name of *distension*. If we accept this, have we created a new name only, or does matter in this condition really show new qualities? It seems to me that we have to deal with a peculiar condition of matter, which deserves a more elaborate study than it has met until now. I will enter again into some special qualities, which have already been mentioned—the photo-electric effect and so on—but I should like to point out that matter in the distension state shows a strongly strengthened absorption of light.

We noticed with regard to ammonium chloride the yellow-greenish after-color of the chlorine. Now, cathode rays, as used in these experiments, will not penetrate any deeper than one-hundredth of a millimeter into the salt. In such a thin layer even pure liquefied chlorine would not show any perceptible color. But besides this it must be noticed that we observe this after-color at the temperature of liquid air, and that chlorine at this temperature, as Dewar and Moissan observed, is snow-white, even in thick layers. In a similar degree the brown color of bromine is weakened at low temperatures. Now, if nevertheless we observe at this very low temperature the marked characteristic colors of chlorine and bromine, we must conclude that the absorptive power of these substances has become a multiple of its ordinary value. One may observe this strengthening of the absorptive power directly in the pure sulphur. Sulphur likewise turns into a snow-white substance if cooled by liquid air. But when the cathode rays fall on the white sulphur it takes immediately a yellow-reddish color. It is a real after-color, because at constant low temperature the color is destroyed by daylight.

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* A paper read before Section A of the British Association at the Australian meeting.

[1] E. Goldstein, *Wiedem. Ann.*, liv, 371; lx, 491; *Phys. Zeitschr.*, iii, 149; *Sitzungsber. Ber. Akad. d. Wiss.*, 1901, 222.

[2] E. Wiedemann and G. C. Schmidt, *Wied. Ann.*, liv, 618.

[3] F. Giesel, *Ber. D. Chem. Ges.*, xxx, 156.

[4] J. Elster and H. Geitel, *Wied. Ann.*, lix, 487.

Now, since the strengthening of light absorption occurs in this elementary substance, it becomes evident that the cause cannot be any chemical process, but only a physical allotropy. The special character of this allotropy (which may be connected with an absorption of electrons) will not be entered on in a discussion here. Probably we have to deal with a polymerization, so that, for instance, the yellow-reddish sulphur would be analogous to polymerized oxygen—to ozone.

I have mentioned already that the first-class after-colors are gradually destroyed by incident daylight. A peculiar phenomenon is connected with this destruction of color. I found that after the daylight had fallen on the colored substances, even for the shortest time, most of them showed a marked phosphorescence of long duration. I have observed this phosphorescence even in substances which had been colored twelve years ago and had been kept in the dark since that time. The diffused dim light of a gloomy November day, when falling through a window on the colored substance for one or two seconds only, is sufficient for the production of this phosphorescence in a marked degree. If you allow the daylight to fall several times on the same spot, then the color is weakened at this spot, and we come to the presumption that the loss of coloration is generally attended by the emission of phosphorescent light. This is in accordance with the experience of Wiedemann and Schmidt that if the destruction of the color is produced by heating, likewise a phosphorescent light is produced, which in this case is strong but of a short duration, corresponding to the quick destruction of the after-colors by strong heating.

If the salts, after having been colored in the condition of a fine powder and then having been put between two glass plates (in order to obtain a plane surface), are placed in a photographic camera instead of the photographic plate, you may get a fine phosphorescent picture of a landscape or of architecture after a very short exposure. Time does not allow me to mention in detail several other peculiarities which are shown by matter in the distension state. In one direction only I may be allowed to make some remarks.

The first-class after-colors may be produced not only by cathode rays, but also by the β rays of radio-active substances, as you probably know. But they may also be produced by *ultra-violet light*, for instance, by ultra-violet spark light, even when a quartz plate is interposed between the spark and the salt. More than thirty years ago I brought forward a hypothesis, according to which in every point where cathode rays strike a solid body a thin layer of ultra-violet light-radiating molecules is produced in the gas, to which ultra-violet light of very short wave-lengths, for instance, the phosphorescence of the glass walls in the cathode rays, is due. But I came further to the assumption that nearly all effects which are commonly ascribed to special qualities of the cathode rays, and likewise of β rays, are mere effects of the ultra-violet light which is produced by the stopping of these rays. I have been guided by this assumption during many years, and have very often been aided by it in foreseeing new phenomena. For instance, in this way I was induced to expect that the after-colors would be produced not only by cathode rays, but also by the ordinary ultra-violet light; further, I could guess that also the X-rays would produce after-colors (which in this case have been observed by Holzknecht), and in recent times I could foresee that solid aromatic substances (the benzine derivatives) in the ultra-violet light must change their spectra of ordinary phosphorescence, composed of broad bands, and turn to peculiar spectra composed of narrow stripes, the wave-lengths of which are characteristic of the single aromatic substances.[5] So I believe also that the after-colors are produced not directly by the cathode rays or by β rays, but by the aforesaid ultra-violet light which is connected with the stopping of the other rays.

In this way the after-colors enter at once into a great class of phenomena known as *reversible effects of light*. You know that certain effects of the visible spectral rays are destroyed by rays of longer wave-lengths, by the infra-red rays. And the analogy to this phenomenon is, in my opinion, the destruction of the after-colors: they are produced by the ultra-violet light of the stopped cathode rays and are annihilated by the longer visible wave-lengths of daylight. In this way you may likewise understand, for instance, that the colored spots, produced by X-rays on the luminescent screens after long exposure, may be destroyed again by exposure of the screens to daylight. You may also explain the peculiar medical observation that therapeutic radium effects in parts of the human body not covered, specially in the face, are often not of long duration, for the face is exposed to the counteracting visible rays of daylight.

We notice here a connection of our subject with a department of great practical importance. For all therapeutic effects of X-rays, radium rays, and mesothorium rays would, according to this view, be effects only of ultra-violet light produced by the stopping of these rays in the human body, and the special character of the radium- and mesothorium- and X-ray treatment would consist mainly in the carriage into the interior of the body, by the rays, of the ultra-violet light, which is not confined to the surface of the body, but is produced at every place where any of the entering rays are stopped. You may notice further that this view of the medical ray-effects presents a heuristic method for the treatment itself, which up to the present followed quite fortuitous and merely empirical paths. For it may be hoped that treatment by radio-active substances will be useful in every disease in which ultra-violet light has been proved to be efficient in some degree; you will avoid such treatment in the well-known cases in which light of short wave-lengths is noxious, and you may be justified in substituting an ultra-violet light treatment where radium or mesothorium is not obtainable. At the same time it becomes evident why the treatment of certain diseases by the β rays has effects very similar to those produced by *fulguration*, that is, by the light of very strong sparks; the efficient agent is in both cases the ultra-violet light.

But it cannot be a physicist's task to enter too far in medical questions; it was only my intention to show how interesting are some of the problems which are connected with the salts colored by cathode rays.

[5] E. Goldstein, *Verhandl. d. D. Physik. Ges.*, xii.

Mutation and Modification of Bacteria*

A Knowledge Which is Important to the Recognition of Species and Kinds

By Sir Ray Lankester, K.C.B., F.R.S.

EVER since we gained (in the later half of last century) a knowledge of the ubiquity and importance of the minute plants called bacteria—as the agents of various "fermentations," including putrefaction and disease—the inquiry has been pursued in various laboratories, under the guidance of various able observers and experimenters, as to whether the "kinds" of bacteria which we can distinguish from one another by their shapes and structure as seen under the microscope and by the different chemical changes, fermentations and diseases to which they give rise, are always distinct "species," as are, for instance, the different "species" of a group of plants—say, the carrot-like family or umbelliferæ. This family presents an enormous number of kinds which breed true and, though in a general way, much alike in appearance, yet having each its own form and producing each its own peculiar chemical substances in its juices. Some of these kinds or "species" are valued by us for flavor, as, for instance, celery, samphire, chervil, fennell, parsley, aniseed, and coriander; while some, such as hemlock, cowbane, and others of the group, are highly poisonous. Do the "kinds" of bacteria breed true as these higher plants do, or can they be largely changed by the influence of light, temperature, moisture, and the nature of the food to which they gain access? The answer to this question has obvious importance in regard to the origin of those diseases which are caused by bacteria.

Closely fitted as most higher plants and animals are to one set of conditions of existence—the change of which leads to their death—yet there is a certain range of toleration, varying in different cases. And sometimes the change tolerated has no obvious effect in altering the plant or animal subjected to the changed conditions; sometimes it results in a change of either the obvious structure or of the more subtle chemical activities, and sometimes of both. Thus some plants, such as the water-hemlock, which are poisonous when growing in marshy, wet land, cease to form a poisonous product when grown in dry soil. The wood of the English oak when grown at the Cape is worthless. Hemp and flax flourish and seed well in the plains of India, but their fibres are brittle and useless. The common rest-harrow when grown in marshy land is devoid of spines, but on a dry soil produces large sharp thorns. The leaves of the white water-buttercup when growing in water are totally different from those of specimens growing on the pond side.

It is, therefore, no exceptional or unexpected thing that a given kind or example of the simple thread-like or rod-like bacteria should be caused to change either in its shape or in its chemical activity and products when the conditions in which it is growing—such as exposure to light, heat, moisture, and various sorts of nutriment—are changed. And, indeed, this has long been a familiar and well-established fact. Some kinds of bacteria seem to be more liable to respond to changes of condition by consequent change in their own form and properties than others. In 1873 I described, under the name "Bacterium rubescens," a peach-colored bacterium which is very common in the decaying vegetable matter of ordinary ponds and rivers and also of salt marshes. I showed that it takes several different forms, namely, (1) rods of various shape, (2) filaments, and (3) minute spheres and ovoids of various sizes, variously aggregated or set together in a jelly or a film of definite pattern, or else freely swimming, according to the nature and abundance of the nutrition supplied to it, and other conditions. It has also been shown to take on a corkscrew shape. I called it a "protean" species, and subsequently this doctrine of the "pleomorphism" of bacteria, a term referring to the multiplicity of shapes which can be assumed by many kinds under diverse conditions, was adopted by Zopf and other writers, and it is now regarded as based on established fact. Some kinds are much more limited in shape and more intolerant of change of conditions of existence than others.

The change of chemical activity of bacteria by change of their conditions of life was first demonstrated and made use of by the great investigator of bacteria, the chemist Pasteur. He found in 1880 that the rod-like bacillus anthracis, taken from the blood of sheep which have died of the disease called "anthrax" in consequence of its presence, can be cultivated on chicken-broth in the laboratory, and that if plenty of oxygen be passed over the surface of the broth and it be kept at a temperature six or seven degrees above blood-heat, the properties of the bacillus are altered after a few hours' growth. It is no longer capable of producing the disease "anthrax" when injected into an animal, not even in a mouse! It has lost its virulence; that is to say, its former special chemical activity. But Pasteur found that animals inoculated with these "attenuated" bacilli proved, subsequently and in consequence, to be completely resistent to the deadly effects of non-attenuated bacilli of anthrax when injected into them. Thus was started a method of protecting sheep and cattle against the deadly disease "anthrax," which on the Continent had been a very serious trouble to farmers, and is now kept in check by Pasteur's inoculation. It was soon discovered that by transferring a disease-causing bacterium or bacillus from one species of animal, in which it was deadly, to another more tolerant of it, the "microbe" (a convenient term for the living "germ," whether bacillus, coccus, or other microscopic organism) could in many cases be "attenuated"—that is to say, its virulence could be reduced. Thus the protection afforded by "vaccination" in small-pox was explained—the small-pox microbe of man becoming attenuated in bovine animals yet serving to render human beings when inoculated with it resistent or "immune" to its poisonous action. The consideration of the theory of this protective action would take us far from the present subject.

A number of cases have been studied in which the chemical activity of bacteria, as tested by the production of recognizable chemical compounds, is altered by culture. The most abundant bacterium in the contents of the intestine of man and animals, called bacillus coli, has been studied in regard to its power of attacking various kinds of sugar (lactose and glucose) forming acids, liberating gas, and also producing imdol when grown on broth. In these respects it acts differently from the "Bacillus typhosus," which is closely similar in form to B. coli, but can do none of these things, and is the cause of typhoid fever. By cultivation of bacillus typhosus on a film of agar jelly, to which the sugar called "lactose," or sugar of milk, was added, various strains of bacilli, with modified properties, have been obtained by a series of investigators. The most important result is that, though B. typhosus cannot ferment lactose, yet after continued cultivation in its presence strains of the cultivation are obtained which actually develop this power, and closely resemble bacillus coli. It seems that the milk-sugar eventually acts on B. typhosus, so as to convert it into B. coli.

* From *The London Daily Telegraph.*

Recently, moreover, Mr. Cecil Revis has experimentally determined (according to his papers published by the Royal Society) marked changes in cultivations of bacillus coli, the purity of which he insured by growing them from a single isolated bacillus, so that there could be no question of the accidental mixing of other kinds in the culture. The same principle of growing a crop of the microbe to be studied, from a single individual, was introduced by Pasteur, and subsequently carried out by Hansen in the investigation of beer-yeast. Mr. Revis cultivated his pure bacillus coli in broth, containing milk-sugar, at blood-heat, and added a small percentage of a chemical called "malachite green" to the broth; in another series of experiments he added "brilliant green." His object was to see whether small quantities of these more or less poisonous chemicals would alter in any way the form and activity of the growing crop of bacillus coli. The green dyes have come into the hands of students of bacteria, in connection with the method of study, which depends on staining these microbes either after death or during life, and many varieties and different colors of these complex chemical dyes have been used. One of these "greens" happens to be described by chemists as the sulphate of tetra ethyl-diamino-triphenyl-methane. It is not an easy name to remember, and there is no reason why anyone should try to do so. But it might be used to mystify the unlearned as successfully as an invocation of "the ultra-violet rays." Mr. Nevis found that the effect of the presence of a little "malachite green" was that a culture of the bacillus coli was produced which was neither in its activities, nor in its form, nor in its mode of growth, a true B. coli, but greatly altered. It had completely lost the power to produce gas, and never regained it. When he used a trace of brilliant green (called also ethyl green) two distinct strains arose in his culture—one *A* modified in form, and retaining in subsequent growth the same modified form, the other *B* undergoing increasing change in continued cultivation, and resulting in a completely different organism. *A* was very small, *B* was relatively large and branching; *A* coagulated milk after seven days' growth, *B* in two days; *A* fermented a certain sugar after twenty days' growth in its presence, *B* not at all. These statements will serve to give some idea of the kind of facts which have to be observed in the pursuit of this question of the alteration of bacteria and bacilli by change of conditions, and it becomes evident that there is no reason for surprise that the ultra-violet rays (which are known to be those rays of the solar emanation which especially excite chemical changes in organic substances, and hence are often called the "chemical rays," as opposed to the "heat rays" at the red end of the solar spectrum) should excite changes in the growth and properties of bacillus anthracis similar to those excited by traces of disturbing chemical drugs.

The various chemical products manufactured by bacteria are thrown out by them into the infusions, solutions, and broths in which they live. Some, such as those which are poisonous and disease-producing, can only be recognized and their variation estimated by inoculating animals with them and watching the result; others are recognized by their smell; others by their production of color, and even of "phosphorescent" light; others by the special chemical fermentations which they excite, and can be precisely measured and distinguished by the analytical chemist. The fact that the peculiar smells and odorous products accompanying bacterial growth are due to the bacteria themselves and not to the kind of material on which they are nourished is demonstrated by the interesting fact that when cultivated in a pure odoriess solution of tartrate of ammonium the putrefactive species of bacteria produce an offensive smell of putrescence, although no organic matter is present. Similarly many bacteria produce brilliant colors—red, yellow, green, and blue—due to chemical compounds which they form and throw out, and these are produced freely in colorless solutions of tartrate of ammonium as readily as when the bacterium is growing on animal or vegetable refuse. My bacterium rubescens is an exception in the fact that the peach-colored pigment which it produces is not thrown out, but remains in the substance of the bacterium and colors it. The coloring matter is called "bacterio-purpurin," and appears to act somewhat in the same way as chlorophyll or leaf-green, assisting the bacterium in its chemical work under the influence of sunlight.

One of the most remarkable color-producing bacteria is that which occasionally appears in large masses on bread, and, since it looks like blood, has on some occasions caused superstitious fears, and even panic (recorded in the legend of the Bloody Host, due to the invasion by this bacterium of the holy wafer). It is known as "bacillus prodigiosus." Races of it occur which are colorless, and from these color-producing races may proceed, when cultivated, some darker, some lighter. It appears that the addition of certain salts to the matter on which the B. prodigiosus is growing leads to the production of white races, and also of dark red races, which are permanent—that is to say, the chemical capacities of the organism are permanently affected.

Another feature in which bacteria vary owing to variation of conditions is in the production of "spores"—minute oval bodies capable of resisting desiccation, and even the heat of boiling water. Only a few bacteria are known to produce these resisting spores (the hay bacillus and the anthrax bacillus are among them), and these kinds sometimes give rise to a changed race or growth, which ceases to produce spores. It is not known what conditions cause this loss of the spore-producing quality, nor whether, when once lost, it can be reacquired. We thus see that there are a number of changes of form, chemical activity, and other important features which a kind or species of bacterium may suddenly exhibit when subjected to change of conditions and surrounding agencies. They all require—and are receiving—further study, in order that their real causes and nature may be understood in the fullest detail, and it is rather absurd to print telegrams in the daily papers about each little fact concerning them as it comes to light.

Some of these alterations or changes are more persistent when once brought about than are others. In some cases the altered bacterium goes on multiplying for as long as it is kept under observation in the laboratory without reverting to its original condition; in other cases it soon reverts, or, on the other hand, may vary still further, and so from one original stock we may obtain three or four more "modified" or "altered" strains, more or less persistent.

It is difficult, perhaps not possible, to compare these changes in bacteria with the variations which arise in the many-celled higher plants and animals. Some variations appearing in higher organisms are passed on to a new generation produced by sexual generation, that is, by the fusion of an egg-cell and a sperm cell; but when a change of some part is caused merely by the direct action of a change of external agencies, it is not passed on to a new generation which is no longer acted upon by that external agency. The bacteria do not reproduce by egg-cells fertilized by sperm-cells, but by simple continuous growth and division, or breaking of the parent into two. Hence the change of constitution produced by changed external conditions is in them more likely to be continued, since the new growths or generations are merely bits of a single minute parental individual which has been more or less profoundly altered throughout its substance. But when we have reproduction by fusion of two small reproductive particles thrown off from two distinct massive parents, it is clear that a change brought about in one parent by conditions which acted on it, but did not act on the other parent, may very well be obliterated by the fusion of its reproductive particle with that of the other unmodified parent (the "fertilization," as it is called, of the ovum by the sperm). And this is the more likely to hold when the modification or change produced by some new external agency is one affecting only a small part of a large, massive plant or animal, and not one altering the parent's entire substance, as is the case in the modified microbe or bacterium. Hence, though the knowledge of these changes in bactria is important in regard to the proper recognition of species and kinds among them, and as to their permanence and derivation or distinctness from one another, we cannot maintain that it throws any light at present on the disputed views put forward by De Vries and others as to the frequency and importance of two kinds of variation (mutations and fluctuations) in sexually reproducing plants and animals. Nor can it be applied to the disputed question as to whether innate or "blastogenic" characters originating in the germ alone are transmissible while acquired changes superinduced on the body (somatogenic character) are not so. There is in the bacteria no distinction between the "germ" and the "body." All we can at present say is that these microbes are liable to undergo, as the result of changed conditions, structural and functional changes, which are in some cases evanescent and in some cases more persistent; but to what extent persistent and why more or less so, we do not yet know.

Those who desire to know more in detail the results and tendencies of recent studies and experiments on bacteria should compare the article on bacteria written by me in Watt's "Dictionary of Chemistry" in 1888 with the masterly essay on bacteriology by the late Prof. Marshall Ward and Prof. Robert Muir in the "Encyclopædia Britannica" in 1910. Twenty-five years ago I wrote in the article above cited: "We have to expect the most important advances in the future from the endeavors of bacteriologists experimentally to breed by change of conditions one kind of bacterium from another, and even to create experimentally new kinds." Those endeavors are, as we have seen, still in progress. The destructive action upon bacteria of the chemical rays of light was known before 1888. Madame Henri has now found that moderate exposure to such light, like moderate doses of chemical poisons, may modify some kinds of bacteria without destroying their life.

The production of such changes of form and function as we have been reviewing in the bacteria has been studied with more striking success in the yeasts and some of the molds which are also minute sexless organisms. It also forms a feature of very great theoretical and practical importance in the proper understanding of the numerous races of Trypanosomes, those ever-wriggling lash-bearing animalcules found in the blood of mammals, birds, reptiles, and fishes, and causing several serious diseases, such as nagana, sleeping sickness, and other horse and cattle plagues. The relationship of the bacteria to the green filamentous Schizophyta—known as oscillatoriæ, which live in fresh waters and on damp rocks and walls—is one of great interest, of which I will write hereafter.

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